

1 The Principles of Scientific Management (1911)

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7  
8 INTRODUCTION

9 President Roosevelt, in his address to the Governors at the White House,  
10 prophetically remarked that "The conservation of our national resources is  
11 only preliminary to the larger question of national efficiency."

12 The whole country at once recognized the importance of conserving our  
13 material resources and a large movement has been started which will be  
14 effective in accomplishing this object. As yet, however, we have but vaguely  
15 appreciated the importance of "the larger question of increasing our national  
16 efficiency."

17 We can see our forests vanishing, our water-powers going to waste, our soil  
18 being carried by floods into the sea; and the end of our coal and our iron is  
19 in sight. But our larger wastes of human effort, which go on every day  
20 through such of our acts as are blundering, ill-directed, or inefficient, and  
21 which Mr. Roosevelt refers to as a lack of "national efficiency," are less  
22 visible, less tangible, and are but vaguely appreciated.

23 We can see and feel the waste of material things. Awkward, inefficient, or  
24 ill-directed movements of men, however, leave nothing visible or tangible  
25 behind them. Their appreciation calls for an act of memory, an effort of the  
26 imagination. And for this reason, even though our daily loss from this source  
27 is greater than from our waste of material things, the one has stirred us  
28 deeply, while the other has moved us but little.

29 As yet there has been no public agitation for "greater national efficiency,"  
30 no meetings have been called to consider how this is to be brought about. And  
31 still there are signs that the need for greater efficiency is widely felt.

32 The search for better, for more competent men, from the presidents of our  
33 great companies down to our household servants, was never more vigorous than  
34 it is now. And more than ever before is the demand for competent men in  
35 excess of the supply.

36 What we are all looking for, however, is the ready-made, competent man; the  
37 man whom some one else has trained. It is only when we fully realize that our  
38 duty, as well as our opportunity, lies in systematically cooperating to train

1 and to make this competent man, instead of in hunting for a man whom some one  
2 else has trained, that we shall be on the road to national efficiency.

3 In the past the prevailing idea has been well expressed in the saying that  
4 "Captains of industry are born, not made" and the theory has been that if one  
5 could get the right man, methods could be safely left to him. In the future  
6 it will be appreciated that our leaders must be trained right as well as born  
7 right, and that no great man can (with the old system of personal management)  
8 hope to compete with a number of ordinary men who have been properly  
9 organized so as efficiently to cooperate.

10 In the past the man has been first; in the future the system must be first.  
11 This in no sense, however, implies that great men are not needed. On the  
12 contrary, the first object of any good system must be that of developing  
13 first-class men; and under systematic management the best man rises to the  
14 top more certainly and more rapidly than ever before.

15 This paper has been written:

16 First. To point out, through a series of simple illustrations, the great loss  
17 which the whole country is suffering through inefficiency in almost all of  
18 our daily acts.

19 Second. To try to convince the reader that the remedy for this inefficiency  
20 lies in systematic management, rather than in searching for some unusual or  
21 extraordinary man.

22 Third. To prove that the best management is a true science, resting upon  
23 clearly defined laws, rules, and principles, as a foundation. And further to  
24 show that the fundamental principles of scientific management are applicable  
25 to all kinds of human activities, from our simplest individual acts to the  
26 work of our great corporations, which call for the most elaborate  
27 cooperation. And, briefly, through a series of illustrations, to convince the  
28 reader that whenever these principles are correctly applied, results must  
29 follow which are truly astounding.

30 This paper was originally prepared for presentation to The American Society  
31 of Mechanical Engineers. The illustrations chosen are such as, it is  
32 believed, will especially appeal to engineers and to managers of industrial  
33 and manufacturing establishments, and also quite as much to all of the men  
34 who are working in these establishments. It is hoped, however, that it will  
35 be clear to other readers that the same principles can be applied with equal  
36 force to all social activities: to the management of our homes; the  
37 management of our farms; the management of the business of our tradesmen,  
38 large and small; of our churches, our philanthropic institutions, our  
39 universities, and our governmental departments.

## 40 41 CHAPTER I: FUNDAMENTALS OF SCIENTIFIC MANAGEMENT

42 THE principal object of management should be to secure the maximum prosperity  
43 for the employer, coupled with the maximum prosperity for each employee.

1 The words "maximum prosperity" are used, in their broad sense, to mean not  
2 only large dividends for the company or owner, but the development of every  
3 branch of the business to its highest state of excellence, so that the  
4 prosperity may be permanent.

5 In the same way maximum prosperity for each employee means not only higher  
6 wages than are usually received by men of his class, but, of more importance  
7 still, it also means the development of each man to his state of maximum  
8 efficiency, so that he may be able to do, generally speaking, the highest  
9 grade of work for which his natural abilities fit him, and it further means  
10 giving him, when possible, this class of work to do.

11 It would seem to be so self-evident that maximum prosperity for the employer,  
12 coupled with maximum prosperity for the employee, ought to be the two leading  
13 objects of management, that even to state this fact should be unnecessary.  
14 And yet there is no question that, throughout the industrial world, a large  
15 part of the organization of employers, as well as employees, is for war  
16 rather than for peace, and that perhaps the majority on either side do not  
17 believe that it is possible so to arrange their mutual relations that their  
18 interests become identical.

19 The majority of these men believe that the fundamental interests of employees  
20 and employers are necessarily antagonistic. Scientific management, on the  
21 contrary, has for its very foundation the firm conviction that the true  
22 interests of the two are one and the same; that prosperity for the employer  
23 cannot exist through a long term of years unless it is accompanied by  
24 prosperity for the employee, and vice versa; and that it is possible to give  
25 the workman what he most wants high wages and the employer what he wants a  
26 low labor cost -- for his manufactures.

27 It is hoped that some at least of those who do not sympathize with each of  
28 these objects may be led to modify their views; that some employers, whose  
29 attitude toward their workmen has been that of trying to get the largest  
30 amount of work out of them for the smallest possible wages, may be led to see  
31 that a more liberal policy toward their men will pay them better; and that  
32 some of those workmen who begrudge a fair and even a large profit to their  
33 employers, and who feel that all of the fruits of their labor should belong  
34 to them, and that those for whom they work and the capital invested in the  
35 business are entitled to little or nothing, may be led to modify these views.

36 No one can be found who will deny that in the case of any single individual  
37 the greatest prosperity can exist only when that individual has reached his  
38 highest state of efficiency; that is, when he is turning out his largest  
39 daily output.

40 The truth of this fact is also perfectly clear in the case of two men working  
41 together. To illustrate: if you and your workman have become so skilful that  
42 you and he together are making two pairs of shoes in a day, while your  
43 competitor and his workman are making only one pair, it is clear that after  
44 selling your two pairs of shoes you can pay your workman much higher wages  
45 than your competitor who produces only one pair of shoes is able to pay his  
46 man, and that there will still be enough money left over for you to have a  
47 larger profit than your competitor.

1 In the case of a more complicated manufacturing establishment, it should also  
2 be perfectly clear that the greatest permanent prosperity for the workman,  
3 coupled with the greatest prosperity for the employer, can be brought about  
4 only when the work of the establishment is done with the smallest combined  
5 expenditure of human effort, plus nature's resources, plus the cost for the  
6 use of capital in the shape of machines, buildings, etc. Or, to state the  
7 same thing in a different way: that the greatest prosperity can exist only as  
8 the result of the greatest possible productivity of the men and machines of  
9 the establishment that is, when each man and each machine are turning out the  
10 largest possible output; because unless your men and your machines are daily  
11 turning out more work than others around you, it is clear that competition  
12 will prevent your paying higher wages to your workmen than are paid to those  
13 of your competitor. And what is true as to the possibility of paying high  
14 wages in the case of two companies competing close beside one another is also  
15 true as to whole districts of the country and even as to nations which are in  
16 competition. In a word, that maximum prosperity can exist only as the result  
17 of maximum productivity. Later in this paper illustrations will be given of  
18 several companies which are earning large dividends and at the same time  
19 paying from 30 per cent to 100 per cent higher wages to their men than are  
20 paid to similar men immediately around them, and with whose employers they  
21 are in competition. These illustrations will cover different types of work,  
22 from the most elementary to the most complicated.

23 If the above reasoning is correct, it follows that the most important object  
24 of both the workmen and the management should be the training and development  
25 of each individual in the establishment, so that he can do (at his fastest  
26 pace and with the maximum of efficiency) the highest class of work for which  
27 his natural abilities fit him.

28 These principles appear to be so self-evident that many men may think it  
29 almost childish to state them. Let us, however, turn to the facts, as they  
30 actually exist in this country and in England. The English and American  
31 peoples are the greatest sportsmen in the world. Whenever an American workman  
32 plays baseball, or an English workman plays cricket, it is safe to say that  
33 he strains every nerve to secure victory for his side. He does his very best  
34 to make the largest possible number of runs. The universal sentiment is so  
35 strong that any man who fails to give out all there is in him in sport is  
36 branded as a "quitter," and treated with contempt by those who are around  
37 him.

38 When the same workman returns to work on the following day, instead of using  
39 every effort to turn out the largest possible amount of work, in a majority  
40 of the cases this man deliberately plans to do as little as he safely can --  
41 to turn out far less work than he is well able to do -- in many instances to  
42 do not more than one-third to one-half of a proper day's work. And in fact if  
43 he were to do his best to turn out his largest possible day's work, he would  
44 be abused by his fellow-workers for so doing, even more than if he had proved  
45 himself a "quitter" in sport. Under working, that is, deliberately working  
46 slowly so as to avoid doing a full day's work, "soldiering," as it is called  
47 in this country, "hanging it out," as it is called in England, "ca canae," as  
48 it is called in Scotland, is almost universal in industrial establishments,  
49 and prevails also to a large extent in the building trades; and the writer  
50 asserts without fear of contradiction that this constitutes the greatest evil  
51 with which the working-people of both England and America are now afflicted.

1 It will be shown later in this paper that doing away with slow working and  
2 "soldiering" in all its forms and so arranging the relations between employer  
3 and employee that each workman will work to his very best advantage and at  
4 his best speed, accompanied by the intimate cooperation with the management  
5 and the help (which the workman should receive) from the management, would  
6 result on the average in nearly doubling the output of each man and each  
7 machine. What other reforms, among those which are being discussed by these  
8 two nations, could do as much toward promoting prosperity, toward the  
9 diminution of poverty, and the alleviation of suffering? America and England  
10 have been recently agitated over such subjects as the tariff, the control of  
11 the large corporations on the one hand, and of hereditary power on the other  
12 hand, and over various more or less socialistic proposals for taxation, etc.  
13 On these subjects both peoples have been profoundly stirred, and yet hardly a  
14 voice has been raised to call attention to this vastly greater and more  
15 important subject of "soldiering," which directly and powerfully affects the  
16 wages, the prosperity, and the life of almost every working-man, and also  
17 quite as much the prosperity of every industrial establishment in the nation.

18 The elimination of "soldiering" and of the several causes of slow working  
19 would so lower the cost of production that both our home and foreign markets  
20 would be greatly enlarged, and we could compete on more than even terms with  
21 our rivals. It would remove one of the fundamental causes for dull times, for  
22 lack of employment, and for poverty, and therefore would have a more  
23 permanent and far-reaching effect upon these misfortunes than any of the  
24 curative remedies that are now being used to soften their consequences. It  
25 would insure higher wages and make shorter working hours and better working  
26 and home conditions possible.

27 Why is it, then, in the face of the self-evident fact that maximum prosperity  
28 can exist only as the result of the determined effort of each workman to turn  
29 out each day his largest possible day's work, that the great majority of our  
30 men are deliberately doing just the opposite, and that even when the men have  
31 the best of intentions their work is in most cases far from efficient?

32 There are three causes for this condition, which may be briefly summarized  
33 as:

34 *First.* The fallacy, which has from time immemorial been almost universal  
35 among workmen, that a material increase in the output of each man or each  
36 machine in the trade would result in the end in throwing a large number of  
37 men out of work.

38 *Second.* The defective systems of management which are in common use, and  
39 which make it necessary for each workman to soldier, or work slowly, in order  
40 that he may protect his own best interests.

41 *Third.* The inefficient rule-of-thumb methods, which are still almost  
42 universal in all trades and in practising which our workmen waste a large  
43 part of their effort.

44 This paper will attempt to show the enormous gains which would result from  
45 the substitution by our workmen of scientific for rule-of-thumb methods.

46 To explain a little more fully these three causes:

1 *First.* The great majority of workmen still believe that if they were to work  
2 at their best speed they would be doing a great injustice to the whole trade  
3 by throwing a lot of men out of work, and yet the history of the development  
4 of each trade shows that each improvement, whether it be the invention of a  
5 new machine or the introduction of a better method, which results in  
6 increasing the productive capacity of the men in the trade and cheapening the  
7 costs, instead of throwing men out of work make in the end work for more men.

8 The cheapening of any article in common use almost immediately results in a  
9 largely increased demand for that article. Take the case of shoes, for  
10 instance. The introduction of machinery for doing every element of the work  
11 which was formerly done by hand has resulted in making shoes at a fraction of  
12 their former labor cost, and in selling them so cheap that now almost every  
13 man, woman, and child in the working-classes buys one or two pairs of shoes  
14 per year, and wears shoes all the time, whereas formerly each workman bought  
15 perhaps one pair of shoes every five years, and went barefoot most of the  
16 time, wearing shoes only as a luxury or as a matter of the sternest  
17 necessity. In spite of the enormously increased output of shoes per workman,  
18 which has come with shoe machinery, the demand for shoes has so increased  
19 that there are relatively more men working in the shoe industry now than ever  
20 before.

21 The workmen in almost every trade have before them an object lesson of this  
22 kind, and yet, because they are ignorant of the history of their own trade  
23 even, they still firmly believe, as their fathers did before them, that it is  
24 against their best interests for each man to turn out each day as much work  
25 as possible.

26 Under this fallacious idea a large proportion of the workmen of both  
27 countries each day deliberately work slowly so as to curtail the output.  
28 Almost every labor union has made, or is contemplating making, rules which  
29 have for their object curtailing the output of their members, and those men  
30 who have the greatest influence with the working-people, the labor leaders as  
31 well as many people with philanthropic feelings who are helping them, are  
32 daily spreading this fallacy and at the same time telling them that they are  
33 overworked.

34 A great deal has been and is being constantly said about "sweat-shop" work  
35 and conditions. The writer has great sympathy with those who are overworked,  
36 but on the whole a greater sympathy for those who are under paid. For every  
37 individual, however, who is overworked, there are a hundred who intentionally  
38 underwork -- greatly underwork -- every day of their lives, and who for this  
39 reason deliberately aid in establishing those conditions which in the end  
40 inevitably result in low wages. And yet hardly a single voice is being raised  
41 in an endeavor to correct this evil.

42 As engineers and managers, we are more intimately acquainted with these facts  
43 than any other class in the community, and are therefore best fitted to lead  
44 in a movement to combat this fallacious idea by educating not only the  
45 workmen but the whole of the country as to the true facts. And yet we are  
46 practically doing nothing in this direction, and are leaving this field  
47 entirely in the hands of the labor agitators (many of whom are misinformed  
48 and mis-guided), and of sentimentalists who are ignorant as to actual working  
49 conditions.

1 *Second.* As to the second cause for soldiering -- the relations which exist  
2 between employers and employees under almost all of the systems of management  
3 which are in common use -- it is impossible in a few words to make it clear  
4 to one not familiar with this problem why it is that the ignorance of  
5 employers as to the proper time in which work of various kinds should be done  
6 makes it for the interest of the workman to "soldier."

7 The writer therefore quotes herewith from a paper read before The American  
8 Society of Mechanical Engineers. in June, 1903, entitled "Shop Management,"  
9 which it is hoped will explain fully this cause for soldiering:

10 "This loafing or soldiering proceeds from two causes. First, from the natural  
11 instinct and tendency of men to take it easy, which may be called natural  
12 soldiering. Second, from more intricate second thought and reasoning caused  
13 by their relations with other men, which may be called systematic soldiering.

14 "There is no question that the tendency of the average man (in all walks of  
15 life) is toward working at a slow, easy gait, and that it is only after a  
16 good deal of thought and observation on his part or as a result of example,  
17 conscience, or external pressure that he takes a more rapid pace.

18 "There are, of course, men of unusual energy, vitality, and ambition who  
19 naturally choose the fastest gait, who set up their own standards, and who  
20 work hard, even though it may be against their best interests. But these few  
21 uncommon men only serve by forming a contrast to emphasize the tendency of  
22 the average.

23 "This common tendency to 'take it easy' is greatly increased by bringing a  
24 number of men together on similar work and at a uniform standard rate of pay  
25 by the day.

26 "Under this plan the better men gradually but surely slow down their gait to  
27 that of the poorest and least efficient. When a naturally energetic man works  
28 for a few days beside a lazy one, the logic of the situation is unanswerable.  
29 'Why should I work hard when that lazy fellow gets the same pay that I do and  
30 does only half as much work?'

31 "A careful time study of men working under these conditions will disclose  
32 facts which are ludicrous as well as pitiable.

33 "To illustrate: The writer has timed a naturally energetic workman who, while  
34 going and coming from work, would walk at a speed of from three to four miles  
35 per hour, and not infrequently trot home after a day's work. On arriving at  
36 his work he would immediately slow down to a speed of about one mile an hour.  
37 When, for example, wheeling a loaded wheelbarrow, he would go at a good fast  
38 pace even uphill in order to be as short a time as possible under load, and  
39 immediately on the return walk slow down to a mile an hour, improving every  
40 opportunity for delay short of actually sitting down. In order to be sure not  
41 to do more than his lazy neighbor, he would actually tire himself in his  
42 effort to go slow.

43 "These men were working under a foreman of good reputation and highly thought  
44 of by his employer, who, when his attention was called to this state of  
45 things, answered: 'Well, I can keep them from sitting down, but the devil  
46 can't make them get a move on while they are at work.'

1 "The natural laziness of men is serious, but by far the greatest evil from  
2 which both workmen and employers are suffering is the systematic soldiering  
3 which is almost universal under all of the ordinary schemes of management and  
4 which results from a careful study on the part of the workmen of what will  
5 promote their best interests.

6 "The writer was much interested recently in hearing one small but experienced  
7 golf caddy boy of twelve explaining to a green caddy, who had shown special  
8 energy and interest, the necessity of going slow and lagging behind his man  
9 when he came up to the ball, showing him that since they were paid by the  
10 hour, the faster they went the less money they got, and finally telling him  
11 that if he went too fast the other boys would give him a licking.

12 "This represents a type of systematic soldiering which is not, however, very  
13 serious, since it is done with the knowledge of the employer, who can quite  
14 easily break it up if he wishes.

15 "The greater part of the systematic soldiering, however, is done by the men  
16 with the deliberate object of keeping their employers ignorant of how fast  
17 work can be done.

18 "So universal is soldiering for this purpose that hardly a competent workman  
19 can be found in a large establishment, whether he works by the day or on  
20 piece work, contract work, or under any of the ordinary systems, who does not  
21 devote a considerable part of his time to studying just how slow he can work  
22 and still convince his employer that he is going at a good pace.

23 "The causes for this are, briefly, that practically all employers determine  
24 upon a maximum sum which they feel it is right for each of their classes of  
25 employees to earn per day, whether their men work by the day or piece.

26 "Each workman soon finds out about what this figure is for his particular  
27 case, and he also realizes that when his employer is convinced that a man is  
28 capable of doing more work than he has done, he will find sooner or later  
29 some way of compelling him to do it with little or no increase of pay.

30 "Employers derive their knowledge of how much of a given class of work can be  
31 done in a day from either their own experience, which has frequently grown  
32 hazy with age, from casual and unsystematic observation of their men, or at  
33 best from records which are kept, showing the quickest time in which each job  
34 has been done. In many cases the employer will feel almost certain that a  
35 given job can be done faster than it has been, but he rarely cares to take  
36 the drastic measures necessary to force men to do it in the quickest time,  
37 unless he has an actual record proving conclusively how fast the work can be  
38 done.

39 "It evidently becomes for each man's interest, then, to see that no job is  
40 done faster than it has been in the past. The younger and less experienced  
41 men are taught this by their elders, and all possible persuasion and social  
42 pressure is brought to bear upon the greedy and selfish men to keep them from  
43 making new records which result in temporarily increasing their wages, while  
44 all those who come after them are made to work harder for the same old pay.

45 "Under the best day work of the ordinary type, when accurate records are kept  
46 of the amount of work done by each man and of his efficiency, and when each

1 man's wages are raised as he improves, and those who fail to rise to a  
2 certain standard are discharged and a fresh supply of carefully selected men  
3 are given work in their places, both the natural loafing and systematic  
4 soldiering can be largely broken up. This can only be done, however, when the  
5 men are thoroughly convinced that there is no intention of establishing piece  
6 work even in the remote future, and it is next to impossible to make men  
7 believe this when the work is of such a nature that they believe piece work  
8 to be practicable. In most cases their fear of making a record which will be  
9 used as a basis for piece work will cause them to soldier as much as they  
10 dare.

11 "It is, however, under piece work that the art of systematic soldiering is  
12 thoroughly developed; after a workman has had the price per piece of the work  
13 he is doing lowered two or three times as a result of his having worked  
14 harder and increased his output, he is likely entirely to lose sight of his  
15 employer's side of the case and become imbued with a grim determination to  
16 have no more cuts if soldiering can prevent it. Unfortunately for the  
17 character of the workman, soldiering involves a deliberate attempt to mislead  
18 and deceive his employer, and thus upright and straightforward workmen are  
19 compelled to become more or less hypocritical. The employer is soon looked  
20 upon as an antagonist, if not an enemy, and the mutual confidence which  
21 should exist between a leader and his men, the enthusiasm, the feeling that  
22 they are all working for the same end and will share in the results is  
23 entirely lacking.

24 "The feeling of antagonism under the ordinary piece-work system becomes in  
25 many cases so marked on the part of the men that any proposition made by  
26 their employers, however reasonable, is looked upon with suspicion, and  
27 soldiering becomes such a fixed habit that men will frequently take pains to  
28 restrict the product of machines which they are running when even a large  
29 increase in output would involve no more work on their part."

30 *Third.* As to the third cause for slow work, considerable space will later in  
31 this paper be devoted to illustrating the great gain, both to employers and  
32 employees, which results from the substitution of scientific for rule-of-  
33 thumb methods in even the smallest details of the work of every trade. The  
34 enormous saving of time and therefore increase in the output which it is  
35 possible to effect through eliminating unnecessary motions and substituting  
36 fast for slow and inefficient motions for the men working in any of our  
37 trades can be fully realized only after one has personally seen the  
38 improvement which results from a thorough motion and time study, made by a  
39 competent man.

40 To explain briefly: owing to the fact that the workmen in all of our trades  
41 have been taught the details of their work by observation of those  
42 immediately around them, there are many different ways in common use for  
43 doing the same thing, perhaps forty, fifty, or a hundred ways of doing each  
44 act in each trade, and for the same reason there is a great variety in the  
45 implements used for each class of work. Now, among the various methods and  
46 implements used in each element of each trade there is always one method and  
47 one implement which is quicker and better than any of the rest. And this one  
48 best method and best implement can only be discovered or developed through a  
49 scientific study and analysis of all of the methods and implements in use,  
50 together with accurate, minute, motion and time study. This involves the  
51 gradual substitution of science for rule of thumb throughout the mechanic  
52 arts.

1 This paper will show that the underlying philosophy of all of the old systems  
2 of management in common use makes it imperative that each workman shall be  
3 left with the final responsibility for doing his job practically as he thinks  
4 best, with comparatively little help and advice from the management. And it  
5 will also show that because of this isolation of workmen, it is in most cases  
6 impossible for the men working under these systems to do their work in  
7 accordance with the rules and laws of a science or art, even where one  
8 exists.

9 The writer asserts as a general principle (and he proposes to give  
10 illustrations tending to prove the fact later in this paper) that in almost  
11 all of the mechanic arts the science which underlies each act of each workman  
12 is so great and amounts to so much that the workman who is best suited to  
13 actually doing the work is incapable of fully understanding this science,  
14 without the guidance and help of those who are working with him or over him,  
15 either through lack of education or through insufficient mental capacity. In  
16 order that the work may be done in accordance with scientific laws, it is  
17 necessary that there shall be a far more equal division of the responsibility  
18 between the management and the workmen than exists under any of the ordinary  
19 types of management. Those in the management whose duty it is to develop this  
20 science should also guide and help the workman in working under it, and  
21 should assume a much larger share of the responsibility for results than  
22 under usual conditions is assumed by the management.

23 The body of this paper will make it clear that, to work according to  
24 scientific laws, the management must take over and perform much of the work  
25 which is now left to the men; almost every act of the workman should be  
26 preceded by one or more preparatory acts of the management which enable him  
27 to do his work better and quicker than he otherwise could. And each man  
28 should daily be taught by and receive the most friendly help from those who  
29 are over him, instead of being, at the one extreme, driven or coerced by his  
30 bosses, and at the other left to his own unaided devices.

31 This close, intimate, personal cooperation between the management and the men  
32 is of the essence of modern scientific or task management.

33 It will be shown by a series of practical illustrations that, through this  
34 friendly cooperation, namely, through sharing equally in every day's burden,  
35 all of the great obstacles (above described) to obtaining the maximum output  
36 for each man and each machine in the establishment are swept away. The 30 per  
37 cent to 100 per cent increase in wages which the workmen are able to earn  
38 beyond what they receive under the old type of management, coupled with the  
39 daily intimate shoulder to shoulder contact with the management, entirely  
40 removes all cause for soldiering. And in a few years, under this system, the  
41 workmen have before them the object lesson of seeing that a great increase in  
42 the output per man results in giving employment to more men, instead of  
43 throwing men out of work, thus completely eradicating the fallacy that a  
44 larger output for each man will throw other men out of work.

45 It is the writer's judgment, then, that while much can be done and should be  
46 done by writing and talking toward educating not only workmen, but all  
47 classes in the community, as to the importance of obtaining the maximum  
48 output of each man and each machine, it is only through the adoption of  
49 modern scientific management that this great problem can be finally solved.  
50 Probably most of the readers of this paper will say that all of this is mere  
51 theory. On the contrary, the theory, or philosophy, of scientific management

1 is just beginning to be understood, whereas the management itself has been a  
2 gradual evolution, extending over a period of nearly thirty years. And during  
3 this time the employees of one company after another, including a large range  
4 and diversity of industries, have gradually changed from the ordinary to the  
5 scientific type of management. At least 50,000 workmen in the United States  
6 are now employed under this system; and they are receiving from 30 per cent  
7 to 100 per cent higher wages daily than are paid to men of similar caliber  
8 with whom they are surrounded, while the companies employing them are more  
9 prosperous than ever before. In these companies the output, per man and per  
10 machine, has on an average been doubled. During all these years there has  
11 never been a single strike among the men working under this system. In place  
12 of the suspicious watchfulness and the more or less open warfare which  
13 characterizes the ordinary types of management, there is universally friendly  
14 cooperation between the management and the men.

15 Several papers have been written, describing the expedients which have been  
16 adopted and the details which have been developed under scientific management  
17 and the steps to be taken in changing from the ordinary to the scientific  
18 type. But unfortunately most of the readers of these papers have mistaken the  
19 mechanism for the true essence. Scientific management fundamentally consists  
20 of certain broad general principles, a certain philosophy, which can be  
21 applied in many ways, and a description of what any one man or men may  
22 believe to be the best mechanism for applying these general principles should  
23 in no way be confused with the principles themselves.

24 It is not here claimed that any single panacea exists for all of the troubles  
25 of the working-people or of employers. As long as some people are born lazy  
26 or inefficient, and others are born greedy and brutal, as long as vice and  
27 crime are with us, just so long will a certain amount of poverty, misery, and  
28 unhappiness be with us also. No system of management, no single expedient  
29 within the control of any man or any set of men can insure continuous  
30 prosperity to either workmen or employers. Prosperity depends upon so many  
31 factors entirely beyond the control of any one set of men, any state, or even  
32 any one country, that certain periods will inevitably come when both sides  
33 must suffer, more or less. It is claimed, however, that under scientific  
34 management the intermediate periods will be far more prosperous, far happier,  
35 and more free from discord and dissension. And also, that the periods will be  
36 fewer, shorter and the suffering less. And this will be particularly true in  
37 any one town, any one section of the country, or any one state which first  
38 substitutes the principles of scientific management for the rule of thumb.

39 That these principles are certain to come into general use practically  
40 throughout the civilized world, sooner or later, the writer is profoundly  
41 convinced, and the sooner they come the better for all the people.

## 42 43 CHAPTER II: THE PRINCIPLES OF SCIENTIFIC MANAGEMENT

44 THE writer has found that there are three questions uppermost in the minds of  
45 men when they become interested in scientific management.

46 *First.* Wherein do the principles of scientific management differ essentially  
47 from those of ordinary management?

1 *Second.* Why are better results attained under scientific management than  
2 under the other types?

3 *Third.* Is not the most important problem that of getting the right man at the  
4 head of the company? And if you have the right man cannot the choice of the  
5 type of management be safely left to him?

6 One of the principal objects of the following pages will be to give a  
7 satisfactory answer to these questions.

## 8 THE FINEST TYPE OF ORDINARY MANAGEMENT

9 Before starting to illustrate the principles of scientific management, or  
10 "task management" as it is briefly called, it seems desirable to outline what  
11 the writer believes will be recognized as the best type of management which  
12 is in common use. This is done so that the great difference between the best  
13 of the ordinary management and scientific management may be fully  
14 appreciated.

15 In an industrial establishment which employs say from 500 to 1000 workmen,  
16 there will be found in many cases at least twenty to thirty different trades.  
17 The workmen in each of these trades have had their knowledge handed down to  
18 them by word of mouth, through the many years in which their trade has been  
19 developed from the primitive condition, in which our far-distant ancestors  
20 each one practised the rudiments of many different trades, to the present  
21 state of great and growing subdivision of labor, in which each man  
22 specializes upon some comparatively small class of work.

23 The ingenuity of each generation has developed quicker and better methods for  
24 doing every element of the work in every trade. Thus the methods which are  
25 now in use may in a broad sense be said to be an evolution representing the  
26 survival of the fittest and best of the ideas which have been developed since  
27 the starting of each trade. However, while this is true in a broad sense,  
28 only those who are intimately acquainted with each of these trades are fully  
29 aware of the fact that in hardly any element of any trade is their uniformity  
30 in the methods which are used. Instead of having only one way which is  
31 generally accepted as a standard, there are in daily use, say, fifty or a  
32 hundred different ways of doing each element of the work. And a little  
33 thought will make it clear that this must inevitably be the case, since our  
34 methods have been handed down from man to man by word of mouth, or have, in  
35 most cases, been almost unconsciously learned through personal observation.  
36 Practically in no instances have they been codified or systematically  
37 analyzed or described. The ingenuity and experience of each generation of  
38 each decade, even, have without doubt handed over better methods to the next.  
39 This mass of rule-of-thumb or traditional knowledge may be said to be the  
40 principal asset or possession of every tradesman. Now, in the best of the  
41 ordinary types of management, the managers recognize frankly the fact that  
42 the 500 or 1000 workmen, included in the twenty to thirty trades, who are  
43 under them, possess this mass of traditional knowledge, a large part of which  
44 is not in the possession of the management. The management, of course,  
45 includes foremen and superintendents, who themselves have been in most cases  
46 first-class workers at their trades. And yet these foremen and  
47 superintendents know, better than any one else, that their own knowledge and  
48 personal skill falls far short of the combined knowledge and dexterity of all  
49 the workmen under them. The most experienced managers therefore frankly place

1 before their workmen the problem of doing the work in the best and most  
2 economical way. They recognize the task before them as that of inducing each  
3 workman to use his best endeavors, his hardest work, all his traditional  
4 knowledge, his skill, his ingenuity, and his good-will in a word, his  
5 "initiative," so as to yield the largest possible return to his employer. The  
6 problem before the management, then, may be briefly said to be that of  
7 obtaining the best initiative of every workman. And the writer uses the word  
8 "initiative" in its broadest sense, to cover all of the good qualities sought  
9 for from the men.

10 On the other hand, no intelligent manager would hope to obtain in any full  
11 measure the initiative of his workmen unless he felt that he was giving them  
12 something more than they usually receive from their employers. Only those  
13 among the readers of this paper who have been managers or who have worked  
14 themselves at a trade realize how far the average workman falls short of  
15 giving his employer his full initiative. It is well within the mark to state  
16 that in nineteen out of twenty industrial establishments the workmen believe  
17 it to be directly against their interests to give their employers their best  
18 initiative, and that instead of working hard to do the largest possible  
19 amount of work and the best quality of work for their employers, they  
20 deliberately work as slowly as they dare while they at the same time try to  
21 make those over them believe that they are working fast.(1)

22 The writer repeats, therefore, that in order to have any hope of obtaining  
23 the initiative of his workmen the manager must give some special incentive to  
24 his men beyond that which is given to the average of the trade. This  
25 incentive can be given in several different ways, as, for example, the hope  
26 of rapid promotion or advancement; higher wages, either in the form of  
27 generous piecework prices or of a premium or bonus of some kind for good and  
28 rapid work; shorter hours of labor; better surroundings and working  
29 conditions than are ordinarily given, etc., and, above all, this special  
30 incentive should be accompanied by that personal consideration for, and  
31 friendly contact with, his workmen which comes only from a genuine and kindly  
32 interest in the welfare of those under him. It is only by giving a special  
33 inducement or "incentive" of this kind that the employer can hope even  
34 approximately to get the "initiative" of his workmen. Under the ordinary type  
35 of management the necessity for offering the workman a special inducement has  
36 come to be so generally recognized that a large proportion of those most  
37 interested in the subject look upon the adoption of some one of the modern  
38 schemes for paying men (such as piece work, the premium plan, or the bonus  
39 plan, for instance) as practically the whole system of management. Under  
40 scientific management, however, the particular pay system which is adopted is  
41 merely one of the subordinate elements.

42 Broadly speaking, then, the best type of management in ordinary use may be  
43 defined as management in which the workmen give their best initiative and in  
44 return receive some special incentive from their employers. This type of  
45 management will be referred to as the management of "initiative and  
46 incentive" in contradistinction to scientific management, or task management,  
47 with which it is to be compared.

48 The writer hopes that the management of "initiative and incentive" will be  
49 recognized as representing the best type in ordinary use, and in fact he  
50 believes that it will be hard to persuade the average manager that anything  
51 better exists in the whole field than this type. The task which the writer  
52 has before him, then, is the difficult one of trying to prove in a thoroughly

convincing way that there is another type of management which is not only better but overwhelmingly better than the management of "initiative and incentive."

The universal prejudice in favor of the management of "initiative and incentive" is so strong that no mere theoretical advantages which can be pointed out will be likely to convince the average manager that any other system is better. It will be upon a series of practical illustrations of the actual working of the two systems that the writer will depend in his efforts to prove that scientific management is so greatly superior to other types. Certain elementary principles, a certain philosophy, will however be recognized as the essence of that which is being illustrated in all of the practical examples which will be given. And the broad principles in which the scientific system differs from the ordinary or "rule-of-thumb" system are so simple in their nature that it seems desirable to describe them before starting with the illustrations.

Under the old type of management success depends almost entirely upon getting the "initiative" of the workmen, and it is indeed a rare case in which this initiative is really attained. Under scientific management the "initiative" of the workmen (that is, their hard work, their good-will, and their ingenuity) is obtained with absolute uniformity and to a greater extent than is possible under the old system; and in addition to this improvement on the part of the men, the managers assume new burdens, new duties, and responsibilities never dreamed of in the past. The managers assume, for instance, the burden of gathering together all of the traditional knowledge which in the past has been possessed by the workmen and then of classifying, tabulating, and reducing this knowledge to rules, laws, and formulæ which are immensely helpful to the workmen in doing their daily work. In addition to developing a *science* in this way, the management take on three other types of duties which involve new and heavy burdens for themselves.

These new duties are grouped under four heads:

*First.* They develop a science for each element of a man's work, which replaces the old rule-of-thumb method.

*Second.* They scientifically select and then train, teach, and develop the workman, whereas in the past he chose his own work and trained himself as best he could.

*Third.* They heartily cooperate with the men so as to insure all of the work being done in accordance with the principles of the science which has been developed.

*Fourth.* There is an almost equal division of the work and the responsibility between the management and the workmen. The management take over all work for which they are better fitted than the workmen, while in the past almost all of the work and the greater part of the responsibility were thrown upon the men.

It is this combination of the initiative of the workmen, coupled with the new types of work done by the management, that makes scientific management so much more efficient than the old plan.

1 Three of these elements exist in many cases, under the management of  
2 "initiative and incentive," in a small and rudimentary way, but they are,  
3 under this management, of minor importance, whereas under scientific  
4 management they form the very essence of the whole system.

5 The fourth of these elements, "an almost equal division of the responsibility  
6 between the management and the workmen," requires further explanation. The  
7 philosophy of the management of "initiative and incentive" makes it necessary  
8 for each workman to bear almost the entire responsibility for the general  
9 plan as well as for each detail of his work, and in many cases for his  
10 implements as well. In addition to this he must do all of the actual physical  
11 labor. The development of a science, on the other hand, involves the  
12 establishment of many rules, laws, and formulæ which replace the judgment of  
13 the individual workman and which can be effectively used only after having  
14 been systematically recorded, indexed, etc. The practical use of scientific  
15 data also calls for a room in which to keep the books, records,(2) etc., and  
16 a desk for the planner to work at. Thus all of the planning which under the  
17 old system was done by the workman, as a result of his personal experience,  
18 must of necessity under the new system be done by the management in  
19 accordance with the laws of the science; because even if the workman was well  
20 suited to the development and use of scientific data, it would be physically  
21 impossible for him to work at his machine and at a desk at the same time. It  
22 is also clear that in most cases one type of man is needed to plan ahead and  
23 an entirely different type to execute the work.

24 The man in the planning room, whose specialty under scientific management is  
25 planning ahead, invariably finds that the work can be done better and more  
26 economically by a subdivision of the labor; each act of each mechanic, for  
27 example, should be preceded by various preparatory acts done by other men.  
28 And all of this involves, as we have said, "an almost equal division of the  
29 responsibility and the work between the management and the workman."

30 To summarize: Under the management of "initiative and incentive" practically  
31 the whole problem is "up to the workman," while under scientific management  
32 fully one-half of the problem is "up to the management."

33 Perhaps the most prominent single element in modern scientific management is  
34 the task idea. The work of every workman is fully planned out by the  
35 management at least one day in advance, and each man receives in most cases  
36 complete written instructions, describing in detail the task which he is to  
37 accomplish, as well as the means to be used in doing the work. And the work  
38 planned in advance in this way constitutes a task which is to be solved, as  
39 explained above, not by the workman alone, but in almost all cases by the  
40 joint effort of the workman and the management. This task specifies not only  
41 what is to be done but how it is to be done and the exact time allowed for  
42 doing it. And whenever the workman succeeds in doing his task right, and  
43 within the time limit specified, he receives an addition of from 30 per cent  
44 to 100 per cent to his ordinary wages. These tasks are carefully planned, so  
45 that both good and careful work are called for in their performance, but it  
46 should be distinctly understood that in no case is the workman called upon to  
47 work at a pace which would be injurious to his health. The task is always so  
48 regulated that the man who is well suited to his job will thrive while  
49 working at this rate during a long term of years and grow happier and more  
50 prosperous, instead of being overworked. Scientific management consists very  
51 largely in preparing for and carrying out these tasks.

1 The writer is fully aware that to perhaps most of the readers of this paper  
2 the four elements which differentiate the new management from the old will at  
3 first appear to be merely high-sounding phrases; and he would again repeat  
4 that he has no idea of convincing the reader of their value merely through  
5 announcing their existence. His hope of carrying conviction rests upon  
6 demonstrating the tremendous force and effect of these four elements through  
7 a series of practical illustrations. It will be shown, first, that they can  
8 be applied absolutely to all classes of work, from the most elementary to the  
9 most intricate; and second, that when they are applied, the results must of  
10 necessity be overwhelmingly greater than those which it is possible to attain  
11 under the management of initiative and incentive.

12 The first illustration is that of handling pig iron, and this work is chosen  
13 because it is typical of perhaps the crudest and most elementary form of  
14 labor which is performed by man. This work is done by men with no other  
15 implements than their hands. The pig-iron handler stoops down, picks up a pig  
16 weighing about 92 pounds, walks for a few feet or yards and then drops it on  
17 to the ground or upon a pile. This work is so crude and elementary in its  
18 nature that the writer firmly believes that it would be possible to train an  
19 intelligent gorilla so as to become a more efficient pig-iron handler than  
20 any man can be. Yet it will be shown that the science of handling pig iron is  
21 so great and amounts to so much that it is impossible for the man who is best  
22 suited to this type of work to understand the principles of this science, or  
23 even to work in accordance with these principles without the aid of a man  
24 better educated than he is. And the further illustrations to be given will  
25 make it clear that in almost all of the mechanic arts the science which  
26 underlies each workman's act is so great and amounts to so much that the  
27 workman who is best suited actually to do the work is incapable (either  
28 through lack of education or through insufficient mental capacity) of  
29 understanding this science. This is announced as a general principle, the  
30 truth of which will become apparent as one illustration after another is  
31 given. After showing these four elements in the handling of pig iron, several  
32 illustrations will be given of their application to different kinds of work  
33 in the field of the mechanic arts, at intervals in a rising scale, beginning  
34 with the simplest and ending with the more intricate forms of labor.

35 One of the first pieces of work undertaken by us, when the writer started to  
36 introduce scientific management into the Bethlehem Steel Company, was to  
37 handle pig iron on task work. The opening of the Spanish War found some  
38 80,000 tons of pig iron placed in small piles in an open field adjoining the  
39 works. Prices for pig iron had been so low that it could not be sold at a  
40 profit, and it therefore had been stored. With the opening of the Spanish War  
41 the price of pig iron rose, and this large accumulation of iron was sold.  
42 This gave us a good opportunity to show the workmen, as well as the owners  
43 and managers of the works, on a fairly large scale the advantages of task  
44 work over the old-fashioned day work and piece work, in doing a very  
45 elementary class of work.

46 The Bethlehem Steel Company had five blast furnaces, the product of which had  
47 been handled by a pig-iron gang for many years. This gang, at this time,  
48 consisted of about 75 men. They were good, average pig-iron handlers, were  
49 under an excellent foreman who himself had been a pig-iron handler, and the  
50 work was done, on the whole, about as fast and as cheaply as it was anywhere  
51 else at that time.

1 A railroad switch was run out into the field, right along the edge of the  
2 piles of pig iron. An inclined plank was placed against the side of a car,  
3 and each man picked up from his pile a pig of iron weighing about 92 pounds,  
4 walked up the inclined plank and dropped it on the end of the car.

5 We found that this gang were loading on the average about 12 1/2 long tons  
6 per man per day. We were surprised to find, after studying the matter, that a  
7 first-class pig-iron handler ought to handle between 47(Note 1) and 48 long  
8 tons per day, instead of 12 1/2 tons. This task seemed to us so very large  
9 that we were obliged to go over our work several times before we were  
10 absolutely sure that we were right. Once we were sure, however, that 47 tons  
11 was a proper day's work for a first-class pig-iron handler, the task which  
12 faced us as managers under the modern scientific plan was clearly before us.  
13 It was our duty to see that the 80,000 tons of pig iron was loaded on to the  
14 cars at the rate of 47 tons per man per day, in place of 12 1/2 tons, at  
15 which rate the work was then being done. And it was further our duty to see  
16 that this work was done without bringing on a strike among the men, without  
17 any quarrel with the men, and to see that the men were happier and better  
18 contented when loading at the new rate of 47 tons than they were when loading  
19 at the old rate of 12 1/2 tons.

20 Our first step was the scientific selection of the workman. In dealing with  
21 workmen under this type of management, it is an inflexible rule to talk to  
22 and deal with only one man at a time, since each workman has his own special  
23 abilities and limitations, and since we are not dealing with men in masses,  
24 but are trying to develop each individual man to his highest state of  
25 efficiency and prosperity. Our first step was to find the proper workman to  
26 begin with. We therefore carefully watched and studied these 75 men for three  
27 or four days, at the end of which time we had picked out four men who  
28 appeared to be physically able to handle pig iron at the rate of 47 tons per  
29 day. A careful study was then made of each of these men.

30 We looked up their history as far back as practicable and thorough inquiries  
31 were made as to the character, habits, and the ambition of each of them.  
32 Finally we selected one from among the four as the most likely man to start  
33 with. He was a little Pennsylvania Dutchman who had been observed to trot  
34 back home for a mile or so after his work in the evening about as fresh as he  
35 was when he came trotting down to work in the morning. We found that upon  
36 wages of \$1.15 a day he had succeeded in buying a small plot of ground, and  
37 that he was engaged in putting up the walls of a little house for himself in  
38 the morning before starting to work and at night after leaving. He also had  
39 the reputation of being exceedingly "close," that is, of placing a very high  
40 value on a dollar. As one man whom we talked to about him said, "A penny  
41 looks about the size of a cart-wheel to him." This man we will call Schmidt.  
42 The task before us, then, narrowed itself down to getting Schmidt to handle  
43 47 tons of pig iron per day and making him glad to do it. This was done as  
44 follows. Schmidt was called out from among the gang of pig-iron handlers and  
45 talked to somewhat in this way:

46 "Schmidt, are you a high-priced man?"

47 "Vell, I don't know vat you mean."

48 "Oh yes, you do. What I want to know is whether you are a high-priced man or  
49 not."

1 "Vell, I don't know vat you mean."

2 "Oh, come now, you answer my questions. what I want to find out is whether  
3 you are a high-priced man or one of these cheap fellows here. What I want to  
4 find out is whether you want to earn \$1.85 a day or whether you are satisfied  
5 with \$1.15, just the same as all those cheap fellows are getting."

6 "Did I vant \$1.85 a day? Vas dot a high-priced man? Vell, yes, I vas a high-  
7 priced man."

8 "Oh, you're aggravating me. Of course you want \$1.85 a day every one wants  
9 it! You know perfectly well that that has very little to do with your being a  
10 high-priced man. For goodness' sake answer my questions, and don't waste any  
11 more of my time. Now come over here. You see that pile of pig iron?"

12 "Yes."

13 "You see that car?"

14 "Yes."

15 "Well, if you are a high-priced man, you will load that pig iron on that car  
16 to-morrow for \$1.85. Now do wake up and answer my question. Tell me whether  
17 you are a high-priced man or not."

18 "Vell -- did I got \$1.85 for loading dot pig iron on dot car to-morrow?"

19 "Yes, of course you do, and you get \$1.85 for loading a pile like that every  
20 day right through the year. That is what a high-priced man does, and you know  
21 it just as well as I do."

22 "Vell, dot's all right. I could load dot pig iron on the car to-morrow for  
23 \$1.85, and I get it every day, don't I?"

24 "Certainly you do -- certainly you do."

25 "Vell, den, I vas a high-priced man."

26 "Now, hold on, hold on. You know just as well as I do that a high-priced man  
27 has to do exactly as he's told from morning till night. You have seen this  
28 man here before, haven't you?"

29 "No, I never saw him."

30 "Well, if you are a high-priced man, you will do exactly as this man tells  
31 you to-morrow, from morning till night. When he tells you to pick up a pig  
32 and walk, you pick it up and you walk, and when he tells you to sit down and  
33 rest, you sit down. You do that right straight through the day. And what's  
34 more, no back talk. Now a high-priced man does just what he's told to do, and  
35 no back talk. Do you understand that? When this man tells you to walk, you  
36 walk; when he tells you to sit down, you sit down, and you don't talk back at  
37 him. Now you come on to work here to-morrow morning and I'll know before  
38 night whether you are really a high-priced man or not."

1 This seems to be rather rough talk. And indeed it would be if applied to an  
2 educated mechanic, or even an intelligent laborer. With a man of the mentally  
3 sluggish type of Schmidt it is appropriate and not unkind, since it is  
4 effective in fixing his attention on the high wages which he wants and away  
5 from what, if it were called to his attention, he probably would consider  
6 impossibly hard work.

7 What would Schmidt's answer be if he were talked to in a manner which is  
8 usual under the management of "initiative and incentive"? say, as follows:

9 "Now, Schmidt, you are a first-class pig-iron handler and know your business  
10 well. You have been handling at the rate of 12 1/2 tons per day. I have given  
11 considerable study to handling pig iron, and feel sure that you could do a  
12 much larger day's work than you have been doing. Now don't you think that if  
13 you really tried you could handle 47 tons of pig iron per day, instead of 12  
14 1/2 tons?"

15 What do you think Schmidt's answer would be to this?

16 Schmidt started to work, and all day long, and at regular intervals, was told  
17 by the man who stood over him with a watch, "Now pick up a pig and walk. Now  
18 sit down and rest. Now walk -- now rest," etc. He worked when he was told to  
19 work, and rested when he was told to rest, and at half-past five in the  
20 afternoon had his 47 1/2 tons loaded on the car. And he practically never  
21 failed to work at this pace and do the task that was set him during the three  
22 years that the writer was at Bethlehem. And throughout this time he averaged  
23 a little more than \$1.85 per day, whereas before he had never received over  
24 \$1.15 per day, which was the ruling rate of wages at that time in Bethlehem.  
25 That is, he received 60 per cent higher wages than were paid to other men who  
26 were not working on task work. One man after another was picked out and  
27 trained to handle pig iron at the rate of 47 1/2 tons per day until all of  
28 the pig iron was handled at this rate, and the men were receiving 60 per cent  
29 more wages than other workmen around them.

30 The writer has given above a brief description of three of the four elements  
31 which constitute the essence of scientific management: first, the careful  
32 selection of the workman, and, second and third, the method of first inducing  
33 and then training and helping the workman to work according to the scientific  
34 method. Nothing has as yet been said about the science of handling pig iron.  
35 The writer trusts, however, that before leaving this illustration the reader  
36 will be thoroughly convinced that there is a science of handling pig iron,  
37 and further that this science amounts to so much that the man who is suited  
38 to handle pig iron cannot possibly understand it, nor even work in accordance  
39 with the laws of this science, without the help of those who are over him.

40 The writer came into the machine-shop of the Midvale Steel Company in 1878,  
41 after having served an apprenticeship as a pattern-maker and as a machinist.  
42 This was close to the end of the long period of depression following the  
43 panic of 1873, and business was so poor that it was impossible for many  
44 mechanics to get work at their trades. For this reason he was obliged to  
45 start as a day laborer instead of working as a mechanic. Fortunately for him,  
46 soon after he came into the shop the clerk of the shop was found stealing.  
47 There was no one else available, and so, having more education than the other  
48 laborers (since he had been prepared for college) he was given the position  
49 of clerk. Shortly after this he was given work as a machinist in running one

1 of the lathes, and, as he turned out rather more work than other machinists  
2 were doing on similar lathes, after several months was made gang boss over  
3 the lathes.

4 Almost all of the work of this shop had been done on piece work for several  
5 years. As was usual then, and in fact as is still usual in most of the shops  
6 in this country, the shop was really run by the workmen, and not by the  
7 bosses. The workmen together had carefully planned just how fast each job  
8 should be done, and they had set a pace for each machine throughout the shop,  
9 which was limited to about one-third of a good day's work. Every new workman  
10 who came into the shop was told at once by the other men exactly how much of  
11 each kind of work he was to do, and unless he obeyed these instructions he  
12 was sure before long to be driven out of the place by the men.

13 As soon as the writer was made gang-boss, one after another of the men came  
14 to him and talked somewhat as follows:

15 "Now, Fred, we're very glad to see that you've been made gang-boss. You know  
16 the game all right, and we're sure that you're not likely to be a piecework  
17 hog. You come along with us, and everything will be all right, but if you try  
18 breaking any of these rates you can be mighty sure that we'll throw you over  
19 the fence."

20 The writer told them plainly that he was now working on the side of the  
21 management, and that he proposed to do whatever he could to get a fair day's  
22 work out of the lathes. This immediately started a war; in most cases a  
23 friendly war, because the men who were under him were his personal friends,  
24 but none the less a war, which as time went on grew more and more bitter. The  
25 writer used every expedient to make them do a fair day's work, such as  
26 discharging or lowering the wages of the more stubborn men who refused to  
27 make any improvement, and such as lowering the piece-work price, hiring green  
28 men, and personally teaching them how to do the work, with the promise from  
29 them that when they had learned how, they would then do a fair day's work.  
30 While the men constantly brought such pressure to bear (both inside and  
31 outside the works) upon all those who started to increase their output that  
32 they were finally compelled to do about as the rest did, or else quit. No one  
33 who has not had this experience can have an idea of the bitterness which is  
34 gradually developed in such a struggle. In a war of this kind the workmen  
35 have one expedient which is usually effective. They use their ingenuity to  
36 contrive various ways in which the machines which they are running are broken  
37 or damaged -- apparently by accident, or in the regular course of work -- and  
38 this they always lay at the door of the foreman, who has forced them to drive  
39 the machine so hard that it is overstrained and is being ruined. And there  
40 are few foremen indeed who are able to stand up against the combined pressure  
41 of all of the men in the shop. In this case the problem was complicated by  
42 the fact that the shop ran both day and night.

43 The writer had two advantages, however, which are not possessed by the  
44 ordinary foreman, and these came, curiously enough, from the fact that he was  
45 not the son of a working man.

46 *First*, owing to the fact that he happened not to be of working parents, the  
47 owners of the company believed that he had the interest of the works more at  
48 heart than the other workmen, and they therefore had more confidence in his  
49 word than they did in that of the machinists who were under him. So that,

1 when the machinists reported to the Superintendent that the machines were  
2 being smashed up because an incompetent foreman was overstraining them, the  
3 Superintendent accepted the word of the writer when he said that these men  
4 were deliberately breaking their machines as a part of the piece-work war  
5 which was going on, and he also allowed the writer to make the only effective  
6 answer to this Vandalism on the part of the men, namely: "There will be no  
7 more accidents to the machines in this shop. If any part of a machine is  
8 broken the man in charge of it must pay at least a part of the cost of its  
9 repair, and the fines collected in this way will all be handed over to the  
10 mutual beneficial association to help care for sick workmen." This soon  
11 stopped the willful breaking of machines.

12 *Second.* If the writer had been one of the workmen, and had lived where they  
13 lived, they would have brought such social pressure to bear upon him that it  
14 would have been impossible to have stood out against them. He would have been  
15 called "scab" and other foul names every time he appeared on the street, his  
16 wife would have been abused, and his children would have been stoned. Once or  
17 twice he was begged by some of his friends among the workmen not to walk  
18 home, about two and a half miles along the lonely path by the side of the  
19 railway. He was told that if he continued to do this it would be at the risk  
20 of his life. In all such cases, however, a display of timidity is apt to  
21 increase rather than diminish the risk, so the writer told these men to say  
22 to the other men in the shop that he proposed to walk home every night right  
23 up that railway track; that he never had carried and never would carry any  
24 weapon of any kind, and that they could shoot and be d -- -- .

25 After about three years of this kind of struggling, the output of the  
26 machines had been materially increased, in many cases doubled, and as a  
27 result the writer had been promoted from one gang-boss-ship to another until  
28 he became foreman of the shop. For any right-minded man, however, this  
29 success is in no sense a recompense for the bitter relations which he is  
30 forced to maintain with all of those around him. Life which is one continuous  
31 struggle with other men is hardly worth living. His workman friends came to  
32 him continually and asked him, in a personal, friendly way, whether he would  
33 advise them, for their own best interest, to turn out more work. And, as a  
34 truthful man, he had to tell them that if he were in their place he would  
35 fight against turning out any more work, just as they were doing, because  
36 under the piecework system they would be allowed to earn no more wages than  
37 they had been earning, and yet they would be made to work harder.

38 Soon after being made foreman, therefore, he decided to make a determined  
39 effort to in some way change the system of management, so that the interests  
40 of the workmen and the management should become the same, instead of  
41 antagonistic. This resulted, some three years later, in the starting of the  
42 type of management which is described in papers presented to the American  
43 Society of Mechanical Engineers entitled "A Piece-Rate System" and "Shop  
44 Management."

45 In preparation for this system the writer realized that the greatest obstacle  
46 to harmonious cooperation between the workmen and the management lay in the  
47 ignorance of the management as to what really constitutes a proper day's work  
48 for a workman. He fully realized that, although he was foreman of the shop,  
49 the combined knowledge and skill of the workmen who were under him was  
50 certainly ten times as great as his own. He therefore obtained the permission  
51 of Mr. William Sellers, who was at that time the President of the Midvale

1 Steel Company, to spend some money in a careful, scientific study of the time  
2 required to do various kinds of work.

3 Mr. Sellers allowed this more as a reward for having, to a certain extent,  
4 "made good" as foreman of the shop in getting more work out of the men, than  
5 for any other reason. He stated, however, that he did not believe that any  
6 scientific study of this sort would give results of much value.

7 Among several investigations which were undertaken at this time, one was an  
8 attempt to find some rule, or law, which would enable a foreman to know in  
9 advance how much of any kind of heavy laboring work a man who was well suited  
10 to his job ought to do in a day; that is, to study the tiring effect of heavy  
11 labor upon a first-class man. Our first step was to employ a young college  
12 graduate to look up all that had been written on the subject in English,  
13 German, and French. Two classes of experiments had been made: one by  
14 physiologists who were studying the endurance of the human animal, and the  
15 other by engineers who wished to determine what fraction of a horse-power a  
16 man-power was. These experiments had been made largely upon men who were  
17 lifting loads by means of turning the crank of a winch from which weights  
18 were suspended, and others who were engaged in walking, running, and lifting  
19 weights in various ways. However, the records of these investigations were so  
20 meager that no law of any value could be deduced from them. We therefore  
21 started a series of experiments of our own.

22 Two first-class laborers were selected, men who had proved themselves to be  
23 physically powerful and who were also good steady workers. These men were  
24 paid double wages during the experiments, and were told that they must work  
25 to the best of their ability at all times, and that we should make certain  
26 tests with them from time to time to find whether they were "soldiering" or  
27 not, and that the moment either one of them started to try to deceive us he  
28 would be discharged. They worked to the best of their ability throughout the  
29 time that they were being observed.

30 Now it must be clearly understood that in these experiments we were not  
31 trying to find the maximum work that a man could do on a short spurt or for a  
32 few days, but that our endeavor was to learn what really constituted a full  
33 day's work for a first-class man; the best day's work that a man could  
34 properly do, year in and year out, and still thrive under. These men were  
35 given all kinds of tasks, which were carried out each day under the close  
36 observation of the young college man who was conducting the experiments, and  
37 who at the same time noted with a stop-watch the proper time for all of the  
38 motions that were made by the men. Every element in any way connected with  
39 the work which we believed could have a bearing on the result was carefully  
40 studied and recorded. What we hoped ultimately to determine was what fraction  
41 of a horse-power a man was able to exert, that is, how many foot-pounds of  
42 work a man could do in a day.

43 After completing this series of experiments, therefore, each man's work for  
44 each day was translated into foot-pounds of energy, and to our surprise we  
45 found that there was no constant or uniform relation between the foot-pounds  
46 of energy which the man exerted during a day and the tiring effect of his  
47 work. On some kinds of work the man would be tired out when doing perhaps not  
48 more than one-eighth of a horse-power, while in others he would be tired to  
49 no greater extent by doing half a horse-power of work. We failed, therefore,  
50 to find any law which was an accurate guide to the maximum day's work for a  
51 first-class workman.

1 A large amount of very valuable data had been obtained, which enabled us to  
2 know, for many kinds of labor, what was a proper day's work. It did not seem  
3 wise, however, at this time to spend any more money in trying to find the  
4 exact law which we were after. Some years later, when more money was  
5 available for this purpose, a second series of experiments was made, similar  
6 to the first, but somewhat more thorough. This, however, resulted as the  
7 first experiments, in obtaining valuable information but not in the  
8 development of a law. Again, some years later, a third series of experiments  
9 was made, and this time no trouble was spared in our endeavor to make the  
10 work thorough. Every minute element which could in anyway affect the problem  
11 was carefully noted and studied, and two college men devoted about three  
12 months to the experiments. After this data was again translated into foot-  
13 pounds of energy exerted for each man each day, it became perfectly clear  
14 that there is no direct relation between the horse-power which a man  
15 exerts(that is, his foot-pounds of energy per day) and the tiring effect of  
16 the work on the man. The writer, however, was quite as firmly convinced as  
17 ever that some definite, clear-cut law existed as to what constitutes a full  
18 day's work for a first-class laborer, and our data had been so carefully  
19 collected and recorded that he felt sure that the necessary information was  
20 included somewhere in the records. The problem of developing this law from  
21 the accumulated facts was therefore handed over to Mr. Carl G. Barth, who is  
22 a better mathematician than any of the rest of us, and we decided to  
23 investigate the problem in a new way, by graphically representing each  
24 element of the work through plotting curves, which should give us, as it  
25 were, a bird's-eye view of every element. In a comparatively short time Mr.  
26 Barth had discovered the law governing the tiring effect of heavy labor on a  
27 first-class man. And it is so simple in its nature that it is truly  
28 remarkable that it should not have been discovered and clearly understood  
29 years before. The law which was developed is as follows:

30 The law is confined to that class of work in which the limit of a man's  
31 capacity is reached because he is tired out. It is the law of heavy laboring,  
32 corresponding to the work of the cart horse, rather than that of the trotter.  
33 Practically all such work consists of a heavy pull or a push on the man's  
34 arms, that is, the man's strength is exerted by either lifting or pushing  
35 something which he grasps in his hands. And the law is that for each given  
36 pull or push on the man's arms it is possible for the workman to be under  
37 load for only a definite percentage of the day. For example, when pig iron is  
38 being handled (each pig weighing 92 pounds), a first-class workman can only  
39 be under load 43 per cent of the day. He must be entirely free from load  
40 during 57 per cent of the day. And as the load becomes lighter, the  
41 percentage of the day under which the man can remain under load increases. So  
42 that, if the workman is handling a half-pig, weighing 46 pounds, he can then  
43 be under load 58 per cent of the day, and only has to rest during 42 per  
44 cent. As the weight grows lighter the man can remain under load during a  
45 larger and larger percentage of the day, until finally a load is reached  
46 which he can carry in his hands all day long without being tired out. When  
47 that point has been arrived at this law ceases to be useful as a guide to a  
48 laborer's endurance, and some other law must be found which indicates the  
49 man's capacity for work.

50 When a laborer is carrying a piece of pig iron weighing 92 pounds in his  
51 hands, it tires him about as much to stand still under the load as it does to  
52 walk with it, since his arm muscles are under the same severe tension whether  
53 he is moving or not. A man, however, who stands still under a load is  
54 exerting no horse-power whatever, and this accounts for the fact that no

1 constant relation could be traced in various kinds of heavy laboring work  
2 between the foot-pounds of energy exerted and the tiring effect of the work  
3 on the man. It will also be clear that in all work of this kind it is  
4 necessary for the arms of the workman to be completely free from load (that  
5 is, for the workman to rest) at frequent intervals. Throughout the time that  
6 the man is under a heavy load the tissues of his arm muscles are in process  
7 of degeneration, and frequent periods of rest are required in order that the  
8 blood may have a chance to restore these tissues to their normal condition.

9 To return now to our pig-iron handlers at the Bethlehem Steel Company. If  
10 Schmidt had been allowed to attack the pile of 47 tons of pig iron without  
11 the guidance or direction of a man who understood the art, or science, of  
12 handling pig iron, in his desire to earn his high wages he would probably  
13 have tired himself out by 11 or 12 o'clock in the day. He would have kept so  
14 steadily at work that his muscles would not have had the proper periods of  
15 rest absolutely needed for recuperation, and he would have been completely  
16 exhausted early in the day. By having a man, however, who understood this  
17 law, stand over him and direct his work, day after day, until he acquired the  
18 habit of resting at proper intervals, he was able to work at an even gait all  
19 day long without unduly tiring himself.

20 Now one of the very first requirements for a man who is fit to handle pig  
21 iron as a regular occupation is that he shall be so stupid and so phlegmatic  
22 that he more nearly resembles in his mental make-up the ox than any other  
23 type. The man who is mentally alert and intelligent is for this very reason  
24 entirely unsuited to what would, for him, be the grinding monotony of work of  
25 this character. Therefore the workman who is best suited to handling pig iron  
26 is unable to understand the real science of doing this class of work. He is  
27 so stupid that the word "percentage" has no meaning to him, and he must  
28 consequently be trained by a man more intelligent than himself into the habit  
29 of working in accordance with the laws of this science before he can be  
30 successful.

31 The writer trusts that it is now clear that even in the case of the most  
32 elementary form of labor that is known, there is a science, and that when the  
33 man best suited to this class of work has been carefully selected, when the  
34 science of doing the work has been developed, and when the carefully selected  
35 man has been trained to work in accordance with this science, the results  
36 obtained must of necessity be overwhelmingly greater than those which are  
37 possible under the plan of "initiative and incentive."

38 Let us, however, again turn to the case of these pig-iron handlers, and see  
39 whether, under the ordinary type of management, it would not have been  
40 possible to obtain practically the same results.

41 The writer has put the problem before many good managers, and asked them  
42 whether, under premium work, piece work, or any of the ordinary plans of  
43 management, they would be likely even to approximate 47 tons(4) per man per  
44 day, and not a man has suggested that an output of over 18 to 25 tons could  
45 be attained by any of the ordinary expedients. It will be remembered that the  
46 Bethlehem men were loading only 12 1/2 tons per man.

47 To go into the matter in more detail, however: As to the scientific selection  
48 of the men, it is a fact that in this gang of 75 pig-iron handlers only about  
49 one man in eight was physically capable of handling 47 1/2 tons per day. With

1 the very best of intentions, the other seven out of eight men were physically  
2 unable to work at this pace. Now the one man in eight who was able to do this  
3 work was in no sense superior to the other men who were working on the gang.  
4 He merely happened to be a man of the type of the ox, no rare specimen of  
5 humanity, difficult to find and therefore very highly prized. On the  
6 contrary, he was a man so stupid that he was unfitted to do most kinds of  
7 laboring work, even. The selection of the man, then, does not involve finding  
8 some extraordinary individual, but merely picking out from among very  
9 ordinary men the few who are especially suited to this type of work. Although  
10 in this particular gang only one man in eight was suited to doing the work,  
11 we had not the slightest difficulty in getting all the men who were needed --  
12 some of them from inside of the works and others from the neighboring country  
13 -- who were exactly suited to the job.

14 Under the management of "initiative and incentive" the attitude of the  
15 management is that of "putting the work up to the workmen." What likelihood  
16 would there be, then, under the old type of management, of these men properly  
17 selecting themselves for pig-iron handling? Would they be likely to get rid  
18 of seven men out of eight from their own gang and retain only the eighth man?  
19 No! And no expedient could be devised which would make these men properly  
20 select themselves. Even if they fully realized the necessity of doing so in  
21 order to obtain high wages (and they are not sufficiently intelligent  
22 properly to grasp this necessity), the fact that their friends or their  
23 brothers who were working right alongside of them would temporarily be thrown  
24 out of a job because they were not suited to this kind of work would entirely  
25 prevent them from properly selecting themselves, that is, from removing the  
26 seven out of eight men on the gang who were unsuited to pig-iron handling.

27 As to the possibility, under the old type of management, of inducing these  
28 pig-iron handlers (after they had been properly selected) to work in  
29 accordance with the science of doing heavy laboring, namely, having proper  
30 scientifically determined periods of rest in close sequence to periods of  
31 work. As has been indicated before, the essential idea of the ordinary types  
32 of management is that each workman has become more skilled in his own trade  
33 than it is possible for any one in the management to be, and that, therefore,  
34 the details of how the work shall best be done must be left to him. The idea,  
35 then, of taking one man after another and training him under a competent  
36 teacher into new working habits until he continually and habitually works in  
37 accordance with scientific laws, which have been developed by some one else,  
38 is directly antagonistic to the old idea that each workman can best regulate  
39 his own way of doing the work. And besides this, the man suited to handling  
40 pig iron is too stupid properly to train himself. Thus it will be seen that  
41 with the ordinary types of management the development of scientific knowledge  
42 to replace rule of thumb, the scientific selection of the men, and inducing  
43 the men to work in accordance with these scientific principles are entirely  
44 out of the question. And this because the philosophy of the old management  
45 puts the entire responsibility upon the workmen, while the philosophy of the  
46 new places a great part of it upon the management.

47 With most readers great sympathy will be aroused because seven out of eight  
48 of these pig-iron handlers were thrown out of a job. This sympathy is  
49 entirely wasted, because almost all of them were immediately given other jobs  
50 with the Bethlehem Steel Company. And indeed it should be understood that the  
51 removal of these men from pig-iron handling, for which they were unfit, was  
52 really a kindness to themselves, because it was the first step toward finding  
53 them work for which they were peculiarly fitted, and at which, after

1 receiving proper training, they could permanently and legitimately earn  
2 higher wages.

3 Although the reader may be convinced that there is a certain science back of  
4 the handling of pig iron, still it is more than likely that he is still  
5 skeptical as to the existence of a science for doing other kinds of laboring.  
6 One of the important objects of this paper is to convince its readers that  
7 every single act of every workman can be reduced to a science. With the hope  
8 of fully convincing the reader of this fact, therefore, the writer proposes  
9 to give several more simple illustrations from among the thousands which are  
10 at hand.

11 For example, the average man would question whether there is much of any  
12 science in the work of shoveling. Yet there is but little doubt, if any  
13 intelligent reader of this paper were deliberately to set out to find what  
14 may be called the foundation of the science of shoveling, that with perhaps  
15 15 to 20 hours of thought and analysis he would be almost sure to have  
16 arrived at the essence of this science. On the other hand, so completely are  
17 the rule-of-thumb ideas still dominant that the writer has never met a single  
18 shovel contractor to whom it had ever even occurred that there was such a  
19 thing as the science of shoveling. This science is so elementary as to be  
20 almost self-evident.

21 For a first-class shoveler there is a given shovel load at which he will do  
22 his biggest day's work. What is this shovel load? Will a first-class man do  
23 more work per day with a shovel load of 5 pounds, 10 pounds, 15 pounds, 20,  
24 25, 30, or 40 pounds? Now this is a question which can be answered only  
25 through carefully made experiments. By first selecting two or three first-  
26 class shovelers, and paying them extra wages for doing trustworthy work, and  
27 then gradually varying the shovel load and having all the conditions  
28 accompanying the work carefully observed for several weeks by men who were  
29 used to experimenting, it was found that a first-class man would do his  
30 biggest day's work with a shovel load of about 21 pounds. For instance, that  
31 this man would shovel a larger tonnage per day with a 21-pound load than with  
32 a 24-pound load or than with an 18-pound load on his shovel. It is, of  
33 course, evident that no shoveler can always take a load of exactly 21 pounds  
34 on his shovel, but nevertheless, although his load may vary 3 or 4 pounds one  
35 way or the other, either below or above the 21 pounds<sup>1</sup> he will do his biggest  
36 day's work when his average for the day is about 21 pounds.

37 The writer does not wish it to be understood that this is the whole of the  
38 art or science of shoveling. There are many other elements, which together go  
39 to make up this science. But he wishes to indicate the important effect which  
40 this one piece of scientific knowledge has upon the work of shoveling.

41 At the works of the Bethlehem Steel Company, for example, as a result of this  
42 law, instead of allowing each shoveler to select and own his own shovel, it  
43 became necessary to provide some 8 to 10 different kinds of shovels, etc.,  
44 each one appropriate to handling a given type of material; not only so as to  
45 enable the men to handle an average load of 21 pounds, but also to adapt the  
46 shovel to several other requirements which become perfectly evident when this  
47 work is studied as a science. A large shovel tool room was built, in which  
48 were stored not only shovels but carefully designed and standardized labor  
49 implements of all kinds, such as picks, crowbars, etc. This made it possible  
50 to issue to each workman a shovel which would hold a load of 21 pounds of  
51 whatever class of material they were to handle: a small shovel for ore, say,

1 or a large one for ashes. Iron ore is one of the heavy materials which are  
2 handled in a works of this kind, and rice coal, owing to the fact that it is  
3 so slippery on the shovel, is one of the lightest materials. And it was found  
4 on studying the rule-of-thumb plan at the Bethlehem Steel Company, where each  
5 shoveler owned his own shovel, that he would frequently go from shoveling  
6 ore, with a load of about 30 pounds per shovel, to handling rice coal, with a  
7 load on the same shovel of less than 4 pounds. In the one case, he was so  
8 overloaded that it was impossible for him to do a full day's work, and in the  
9 other case he was so ridiculously underloaded that it was manifestly  
10 impossible to even approximate a day's work.

11 Briefly to illustrate some of the other elements which go to make up the  
12 science of shoveling, thousands of stop-watch observations were made to study  
13 just how quickly a laborer, provided in each case with the proper type of  
14 shovel, can push his shovel into the pile of materials and then draw it out  
15 properly loaded. These observations were made first when pushing the shovel  
16 into the body of the pile. Next when shoveling on a dirt bottom, that is, at  
17 the outside edge of the pile, and next with a wooden bottom, and finally with  
18 an iron bottom. Again a similar accurate time study was made of the time  
19 required to swing the shovel backward and then throw the load for a given  
20 horizontal distance, accompanied by a given height. This time study was made  
21 for various combinations of distance and height. With data of this sort  
22 before him, coupled with the law of endurance described in the case of the  
23 pig-iron handlers, it is evident that the man who is directing shovelers can  
24 first teach them the exact methods which should be employed to use their  
25 strength to the very best advantage, and can then assign them daily tasks  
26 which are so just that the workman can each day be sure of earning the large  
27 bonus which is paid whenever he successfully performs this task.

28 There were about 600 shovelers and laborers of this general class in the yard  
29 of the Bethlehem Steel Company at this time. These men were scattered in  
30 their work over a yard which was, roughly, about two miles long and half a  
31 mile wide. In order that each workman should be given his proper implement  
32 and his proper instructions for doing each new job, it was necessary to  
33 establish a detailed system for directing men in their work, in place of the  
34 old plan of handling them in large groups, or gangs, under a few yard  
35 foremen. As each workman came into the works in the morning, he took out of  
36 his own special pigeonhole, with his number on the outside, two pieces of  
37 paper, one of which stated just what implements he was to get from the tool  
38 room and where he was to start to work, and the second of which gave the  
39 history of his previous day's work; that is, a statement of the work which he  
40 had done, how much he had earned the day before, etc. Many of these men were  
41 foreigners and unable to read and write, but they all knew at a glance the  
42 essence of this report, because yellow paper showed the man that he had  
43 failed to do his full task the day before, and informed him that he had not  
44 earned as much as \$1.85 a day, and that none but high-priced men would be  
45 allowed to stay permanently with this gang. The hope was further expressed  
46 that he would earn his full wages on the following day. So that whenever the  
47 men received white slips they knew that everything was all right, and  
48 whenever they received yellow slips they realized that they must do better or  
49 they would be shifted to some other class of work.

50 Dealing with every workman as a separate individual in this way involved the  
51 building of a labor office for the superintendent and clerks who were in  
52 charge of this section of the work. In this office every laborer's work was  
53 planned out well in advance, and the workmen were all moved from place to

1 place by the clerks with elaborate diagrams or maps of the yard before them,  
2 very much as chessmen are moved on a chess-board, a telephone and messenger  
3 system having been installed for this purpose. In this way a large amount of  
4 the time lost through having too many men in one place and too few in  
5 another, and through waiting between jobs, was entirely eliminated. Under the  
6 old system the workmen were kept day after day in comparatively large gangs,  
7 each under a single foreman, and the gang was apt to remain of pretty nearly  
8 the same size whether there was much or little of the particular kind of work  
9 on hand which this foreman had under his charge, since each gang had to be  
10 kept large enough to handle whatever work in its special line was likely to  
11 come along.

12 When one ceases to deal with men in large gangs or groups, and proceeds to  
13 study each workman as an individual, if the workman fails to do his task,  
14 some competent teacher should be sent to show him exactly how his work can  
15 best be done, to guide, help, and encourage him, and, at the same time, to  
16 study his possibilities as a workman. So that, under the plan which  
17 individualizes each workman, instead of brutally discharging the man or  
18 lowering his wages for failing to make good at once, he is given the time and  
19 the help required to make him proficient at his present job, or he is shifted  
20 to another class of work for which he is either mentally or physically better  
21 suited.

22 All of this requires the kindly cooperation of the management, and involves a  
23 much more elaborate organization and system than the old-fashioned herding of  
24 men in large gangs. This organization consisted, in this case, of one set of  
25 men, who were engaged in the development of the science of laboring through  
26 time study, such as has been described above; another set of men, mostly  
27 skilled laborers themselves, who were teachers, and who helped and guided the  
28 men in their work; another set of tool-room men who provided them with the  
29 proper implements and kept them in perfect order, and another set of clerks  
30 who planned the work well in advance, moved the men with the least loss of  
31 time from one place to another, and properly recorded each man's earnings,  
32 etc. And this furnishes an elementary illustration of what has been referred  
33 to as cooperation between the management and the workmen.

34 The question which naturally presents itself is whether an elaborate  
35 organization of this sort can be made to pay for itself; whether such an  
36 organization is not top-heavy. This question will best be answered by a  
37 statement of the results of the third year of working under this plan.

38  
39 The number of yard laborers was reduced from between 400 & 600 down to about  
40 140

41 Average number of tons per man per day went from 16 to 59

42 Average earnings per man per day went from \$1.15 to \$1.88

43 Average cost of handling a ton of 2240 lbs went from \$0.072 down to \$0.033

1 And in computing the low cost of \$0.033 per ton, the office and tool-room  
2 expenses, and the wages of all labor superintendents, foremen, clerks, time-  
3 study men, etc., are included.

4 During this year the total saving of the new plan over the old amounted to  
5 \$36,417.69, and during the six months following, when all of the work of the  
6 yard was on task work, the saving was at the rate of between \$75,000 and  
7 \$80,000 per year.

8 Perhaps the most important of all the results attained was the effect on the  
9 workmen themselves. A careful inquiry into the condition of these men  
10 developed the fact that out of the 140 workmen only two were said to be  
11 drinking men. This does not, of course, imply that many of them did not take  
12 an occasional drink. The fact is that a steady drinker would find it almost  
13 impossible to keep up with the pace which was set, so that they were  
14 practically all sober. Many, if not most of them, were saving money, and they  
15 all lived better than they had before. These men constituted the finest body  
16 of picked laborers that the writer has ever seen together, and they looked  
17 upon the men who were over them, their bosses and their teachers, as their  
18 very best friends; not as nigger drivers, forcing them to work extra hard for  
19 ordinary wages, but as friends who were teaching them and helping them to  
20 earn much higher wages than they had ever earned before. It would have been  
21 absolutely impossible for any one to have stirred up strife between these men  
22 and their employers. And this presents a very simple though effective  
23 illustration of what is meant by the words "prosperity for the employee,  
24 coupled with prosperity for the employer," the two principal objects of  
25 management. It is evident also that this result has been brought about by the  
26 application of the four fundamental principles of scientific management.

27 As another illustration of the value of a scientific study of the motives  
28 which influence workmen in their daily work, the loss of ambition and  
29 initiative will be cited, which takes place in workmen when they are herded  
30 into gangs instead of being treated as separate individuals. A careful  
31 analysis had demonstrated the fact that when workmen are herded together in  
32 gangs, each man in the gang becomes far less efficient than when his personal  
33 ambition is stimulated; that when men work in gangs, their individual  
34 efficiency falls almost invariably down to or below the level of the worst  
35 man in the gang; and that they are all pulled down instead of being elevated  
36 by being herded together. For this reason a general order had been issued in  
37 the Bethlehem Steel Works that not more than four men were to be allowed to  
38 work in a labor gang without a special permit, signed by the General  
39 Superintendent of the works, this special permit to extend for one week only.  
40 it was arranged that as far as possible each laborer should be given a  
41 separate individual task. As there were about 5000 men at work in the  
42 establishment, the General Superintendent had so much to do that there was  
43 but little time left for signing these special permits.

44 After gang work had been by this means broken up, an unusually fine set of  
45 ore shovelers had been developed, through careful selection and individual,  
46 scientific training. Each of these men was given a separate ear to unload  
47 each day, and his wages depended upon his own personal work. The man who  
48 unloaded the largest amount of ore was paid the highest wages, and an unusual  
49 opportunity came for demonstrating the importance of individualizing each  
50 workman. Much of this ore came from the Lake Superior region, and the same  
51 ore was delivered both in Pittsburg and in Bethlehem in exactly similar cars.  
52 There was a shortage of ore handlers in Pittsburg, and hearing of the fine

gang of laborers that had been developed at Bethlehem, one of the Pittsburgh steel works sent an agent to hire the Bethlehem men. The Pittsburgh men offered 4 9/10 cents a ton for unloading exactly the same ore, with the same shovels, from the same cars, that were unloaded in Bethlehem for 3 2/10 cents a ton. After carefully considering this situation, it was decided that it would be unwise to pay more than 3 2/10 cents per ton for unloading the Bethlehem cars, because, at this rate, the Bethlehem laborers were earning a little over \$1.85 per man per day, and this price was 60 per cent more than the ruling rate of wages around Bethlehem.

A long series of experiments, coupled with close observation, had demonstrated the fact that when workmen of this caliber are given a carefully measured task, which calls for a big day's work on their part, and that when in return for this extra effort they are paid wages up to 60 per cent beyond the wages usually paid, that this increase in wages tends to make them not only more thrifty but better men in every way; that they live rather better, begin to save money, become more sober, and work more steadily. When, on the other hand, they receive much more than a 60 per cent increase in wages, many of them will work irregularly and tend to become more or less shiftless, extravagant, and dissipated. Our experiments showed, in other words, that it does not do for most men to get rich too fast.

After deciding, for this reason, not to raise the wages of our ore handlers, these men were brought into the office one at a time, and talked to somewhat as follows:

"Now, Patrick, you have proved to us that you are a high-priced man. You have been earning every day a little more than \$1.85, and you are just the sort of man that we want to have in our ore-shoveling gang. A man has come here from Pittsburgh, who is offering 4 9/10 cents per ton for handling ore while we can pay only 3 2/10 cents per ton. I think, therefore, that you had better apply to this man for a job. Of course, you know we are very sorry to have you leave us, but you have proved yourself a high-priced man, and we are very glad to see you get this chance of earning more money. Just remember, however, that at any time in the future, when you get out of a job, you can always come right back to us. There will always be a job for a high-priced man like you in our gang here."

Almost all of the ore handlers took this advice, and went to Pittsburgh, but in about six weeks most of them were again back in Bethlehem unloading ore at the old rate of 3 2/10 cents a ton. The writer had the following talk with one of these men after he had returned:

"Patrick, what are you doing back here? I thought we had gotten rid of you."

"Well, sir, I'll tell you how it was. When we got out there Jimmy and I were put on to a car with eight other men. We started to shovel the ore out just the same as we do here. After about half an hour I saw a little devil alongside of me doing pretty near nothing, so I said to him, 'Why don't you go to work? Unless we get the ore out of this car we won't get any money on pay-day.' He turned to me and said, 'Who in -- -- -- are you?' 'Well,' I said, 'that's none of your business'; and the little devil stood up to me and said, 'You'll be minding your own business, or I'll throw you off this car!' 'Well, I could have spit on him and drowned him, but the rest of the men put down their shovels and looked as if they were going to back him up; so I went

1 round to Jimmy and said (so that the whole gang could hear it), 'Now, Jimmy,  
2 you and I will throw a shovelful whenever this little devil throws one, and  
3 not another shovelful.' So we watched him, and only shoveled when he  
4 shoveled. -- When pay-day came around, though, we had less money than we got  
5 here at Bethlehem. After that Jimmy and I went in to the boss, and asked him  
6 for a car to ourselves, the same as we got at Bethlehem, but he told us to  
7 mind our own business. And when another pay-day came around we had less money  
8 than we got here at Bethlehem, so Jimmy and I got the gang together and  
9 brought them all back here to work again."

10 When working each man for himself, these men were able to earn higher wages  
11 at 3 2/10 cents a ton than they could earn when they were paid 4 9/10 cents a  
12 ton on gang work; and this again shows the great gain which results from  
13 working according to even the most elementary of scientific principles. But  
14 it also shows that in the application of the most elementary principles it is  
15 necessary for the management to do their share of the work in cooperating  
16 with the workmen. The Pittsburg managers knew just how the results had been  
17 attained at Bethlehem, but they were unwilling to go to the small trouble and  
18 expense required to plan ahead and assign a separate car to each shoveler,  
19 and then keep an individual record of each man's work, and pay him just what  
20 he had earned.

21 Bricklaying is one of the oldest of our trades. For hundreds of years there  
22 has been little or no improvement made in the implements and materials used  
23 in this trade, nor in fact in the method of laying bricks. In spite of the  
24 millions of men who have practised this trade, no great improvement has been  
25 evolved for many generations. Here, then, at least, one would expect to find  
26 but little gain possible through scientific analysis and study. Mr. Frank B.  
27 Gilbreth, a member of our Society, who had himself studied bricklaying in his  
28 youth, became interested in the principles of scientific management, and  
29 decided to apply them to the art of bricklaying. He made an intensely  
30 interesting analysis and study of each movement of the bricklayer, and one  
31 after another eliminated all unnecessary movements and substituted fast for  
32 slow motions. He experimented with every minute element which in any way  
33 affects the speed and the tiring of the bricklayer.

34 He developed the exact position which each of the feet of the bricklayer  
35 should occupy with relation to the wall, the mortar box, and the pile of  
36 bricks, and so made it unnecessary for him to take a step or two toward the  
37 pile of bricks and back again each time a brick is laid.

38 He studied the best height for the mortar box and brick pile, and then  
39 designed a scaffold, with a table on it, upon which all of the materials are  
40 placed, so as to keep the bricks, the mortar, the man, and the wall in their  
41 proper relative positions. These scaffolds are adjusted, as the wall grows in  
42 height, for all of the bricklayers by a laborer especially detailed for this  
43 purpose, and by this means the bricklayer is saved the exertion of stooping  
44 down to the level of his feet for each brick and each trowelful of mortar and  
45 then straightening up again. Think of the waste of effort that has gone on  
46 through all these years, with each bricklayer lowering his body, weighing,  
47 say, 150 pounds, down two feet and raising it up again every time a brick  
48 (weighing about 5 pounds) is laid in the wall! And this each bricklayer did  
49 about one thousand times a day.

50 As a result of further study, after the bricks are unloaded from the cars,  
51 and before bringing them to the bricklayer, they are carefully sorted by a

1 laborer, and placed with their best edge up on a simple wooden frame,  
2 constructed so as to enable him to take hold of each brick in the quickest  
3 time and in the most advantageous position. In this way the bricklayer avoids  
4 either having to turn the brick over or end for end to examine it before  
5 laying it, and he saves, also, the time taken in deciding which is the best  
6 edge and end to place on the outside of the wall. In most cases, also, he  
7 saves the time taken in disentangling the brick from a disorderly pile on the  
8 scaffold. This "pack" of bricks (as Mr. Gilbreth calls his loaded wooden  
9 frames) is placed by the helper in its proper position on the adjustable  
10 scaffold close to the mortar box.

11 We have all been used to seeing bricklayers tap each brick after it is placed  
12 on its bed of mortar several times with the end of the handle of the trowel  
13 so as to secure the right thickness for the joint. Mr. Gilbreth found that by  
14 tempering the mortar just right, the bricks could be readily bedded to the  
15 proper depth by a downward pressure of the hand with which they are laid. He  
16 insisted that his mortar mixers should give special attention to tempering  
17 the mortar, and so save the time consumed in tapping the brick.

18 Through all of this minute study of the motions to be made by the bricklayer  
19 in laying bricks under standard conditions, Mr. Gilbreth has reduced his  
20 movements from eighteen motions per brick to five, and even in one case to as  
21 low as two motions per brick. He has given all of the details of this  
22 analysis to the profession in the chapter headed "Motion Study," of his book  
23 entitled "Bricklaying System," published by Myron C. Clerk Publishing  
24 Company, New York and Chicago; E. F. N. Spon, of London.

25 An analysis of the expedients used by Mr. Gilbreth in reducing the motions of  
26 his bricklayers from eighteen to five shows that this improvement has been  
27 made in three different ways:

28 *First.* He has entirely dispensed with certain movements which the bricklayers  
29 in the past believed were necessary; but which a careful study and trial on  
30 his part have shown to be useless.

31 *Second.* He has introduced simple apparatus, such as his adjustable scaffold  
32 and his packets for holding the bricks, by means of which, with a very small  
33 amount of cooperation from a cheap laborer, he entirely eliminates a lot of  
34 tiresome and time-consuming motions which are necessary for the bricklayer  
35 who lacks the scaffold and the packet.

36 *Third.* He teaches his bricklayers to make simple motions with both hands at  
37 the same time, where before they completed a motion with the right hand and  
38 followed it later with one from the left hand.

39 For example, Mr. Gilbreth teaches his bricklayer to pick up a brick in the  
40 left hand at the same instant that he takes a trowelful of mortar with the  
41 right hand. This work with two hands at the same time is, of course, made  
42 possible by substituting a deep mortar box for the old mortar board (on which  
43 the mortar spread out so thin that a step or two had to be taken to reach it)  
44 and then placing the mortar box and the brick pile close together, and at the  
45 proper height on his new scaffold.

46 These three kinds of improvements are typical of the ways in which needless  
47 motions can be entirely eliminated and quicker types of movements substituted

1 for slow movements when scientific motion study, as Mr. Gilbreth calls his  
2 analysis, time study, as the writer has called similar work, are applied in  
3 any trade.

4 Most practical men would (knowing the opposition of almost all tradesmen to  
5 making any change in their methods and habits), however, be skeptical as to  
6 the possibility of actually achieving any large results from a study of this  
7 sort. Mr. Gilbreth reports that a few months ago, in a large brick building  
8 which he erected, he demonstrated on a commercial scale the great gain which  
9 is possible from practically applying his scientific study. With union  
10 bricklayers, in laying a factory wall, twelve inches thick, with two kinds of  
11 brick, faced and ruled joints on both sides of the wall, he averaged, after  
12 his selected workmen had become skilful in his new methods, 350 bricks per  
13 man per hour; whereas the average speed of doing this work with the old  
14 methods was, in that section of the country, 120 bricks per man per hour. His  
15 bricklayers were taught his new method of bricklaying by their foreman. These  
16 who failed to profit by their teaching were dropped, and each man, as he  
17 became proficient under the new method, received a substantial (not a small)  
18 increase in his wages. With a view to individualizing his workmen and  
19 stimulating each man to do his best, Mr. Gilbreth also developed an ingenious  
20 method for measuring and recording the number of bricks laid by each man, and  
21 for telling each workman at frequent intervals how many bricks he had  
22 succeeded in laying.

23 It is only when this work is compared with the conditions which prevail under  
24 the tyranny of some of our misguided bricklayers' unions that the great waste  
25 of human effort which is going on will be realized. In one foreign city the  
26 bricklayers union have restricted their men to 275 bricks per day on work of  
27 this character when working for the city, and 375 per day when working for  
28 private owners. The members of this union are probably sincere in their  
29 belief that this restriction of output is a benefit to their trade. It should  
30 be plain to all men, however, that this deliberate loafing is almost  
31 criminal, in that it inevitably results in making every workman's family pay  
32 higher rent for their housing, and also in the end drives work and trade away  
33 from their city, instead of bringing it to it.

34 Why is it, in a trade which has been continually practised since before the  
35 Christian era, and with implements practically the same as they now are, that  
36 this simplification of the bricklayer's movements, this great gain, has not  
37 been made before?

38 It is highly likely that many times during all of these years individual  
39 bricklayers have recognized the possibility of eliminating each of these  
40 unnecessary motions. But even if, in the past, he did invent each one of Mr.  
41 Gilbreth's improvements, no bricklayer could alone increase his speed through  
42 their adoption because it will be remembered that in all cases several  
43 bricklayers work together in a row and that the walls all around a building  
44 must grow at the same rate of speed. No one bricklayer, then, can work much  
45 faster than the one next to him. Nor has any one workman the authority to  
46 make other men cooperate with him to do faster work. It is only through  
47 *enforced* standardization of methods, *enforced* adoption of the best implements  
48 and working conditions, and enforced cooperation that this faster work can be  
49 assured. And the duty of enforcing the adoption of standards and of enforcing  
50 this cooperation rests with the *management* alone. The *management* must supply  
51 continually one or more teachers to show each new man the new and simpler  
52 motions, and the slower men must be constantly watched and helped until they

1 have risen to their proper speed. All of those who, after proper teaching,  
2 either will not or cannot work in accordance with the new methods and at the  
3 higher speed must be discharged by the *management*. The *management* must also  
4 recognize the broad fact that workmen will not submit to this more rigid  
5 standardization and will not work extra hard, unless they receive extra pay  
6 for doing it.

7 All of this involves an individual study of and treatment for each man, while  
8 in the past they have been handled in large groups.

9 The *management* must also see that those who prepare the bricks and the mortar  
10 and adjust the scaffold, etc., for the bricklayers, cooperate with them by  
11 doing their work just right and always on time; and they must also inform  
12 each bricklayer at frequent intervals as to the progress he is making, so  
13 that he may not unintentionally fall off in his pace. Thus it will be seen  
14 that it is the assumption by the management of new duties and new kinds of  
15 work never done by employers in the past that makes this great improvement  
16 possible, and that, without this new help from the management, the workman  
17 even with full knowledge of the new methods and with the best of intentions  
18 could not attain these startling results.

19 Mr. Gilbreth's method of bricklaying furnishes a simple illustration of true  
20 and effective cooperation. Not the type of cooperation in which a mass of  
21 workmen on one side together cooperate with the management; but that in which  
22 several men in the management (each one in his own particular way) help each  
23 workman individually, on the one hand, by studying his needs and his  
24 shortcomings and teaching him better and quicker methods, and, on the other  
25 hand, by seeing that all other workmen with whom he comes in contact help and  
26 cooperate with him by doing their part of the work right and fast.

27 The writer has gone thus fully into Mr. Gilbreth's method in order that it  
28 may be perfectly clear that this increase in output and that this harmony  
29 could not have been attained under the management of "initiative and  
30 incentive" (that is, by putting the problem up to the workman and leaving him  
31 to solve it alone) which has been the philosophy of the past. And that his  
32 success has been due to the use of the four elements which constitute the  
33 essence of scientific management.

34 *First*. The development (by the management, not the workman) of the science of  
35 bricklaying, with rigid rules for each motion of every man, and the  
36 perfection and standardization of all implements and working conditions.

37 *Second*. The careful selection and subsequent training of the bricklayers into  
38 first-class men, and the elimination of all men who refuse to or are unable  
39 to adopt the best methods.

40 *Third*. Bringing the first-class bricklayer and the science of bricklaying  
41 together, through the constant help and watchfulness of the management, and  
42 through paying each man a large daily bonus for working fast and doing what  
43 he is told to do.

44 *Fourth*. An almost equal division of the work and responsibility between the  
45 workman and the management. All day long the management work almost side by  
46 side with the men, helping, encouraging, and smoothing the way for them,  
47 while in the past they stood one side, gave the men but little help, and

1   threw on to them almost the entire responsibility as to methods, implements,  
2   speed, and harmonious cooperation.

3   Of these four elements, the first (the development of the science of  
4   bricklaying) is the most interesting and spectacular. Each of the three  
5   others is, however, quite as necessary for success.

6   It must not be forgotten that back of all this, and directing it, there must  
7   be the optimistic, determined, and hard-working leader who can wait patiently  
8   as well as work.

9   In most cases (particularly when the work to be done is intricate in its  
10   nature) the "development of the science" is the most important of the four  
11   great elements of the new management. There are instances, however, in which  
12   the "scientific selection of the workman" counts for more than anything else.

13   A case of this type is well illustrated in the very simple though unusual  
14   work of inspecting bicycle balls. When the bicycle craze was at its height  
15   some years ago several million small balls made of hardened steel were used  
16   annually in bicycle bearings. And among the twenty or more operations used in  
17   making steel balls, perhaps the most important was that of inspecting them  
18   after final polishing so as to remove all fire-cracked or otherwise imperfect  
19   balls before boxing.

20   The writer was given the task of systematizing the largest bicycle ball  
21   factory in this country. This company had been running for from eight to ten  
22   years on ordinary day work before he undertook its reorganization, so that  
23   the one hundred and twenty or more girls who were inspecting the balls were  
24   "old hands" and skilled at their jobs. It is impossible even in the most  
25   elementary work to change rapidly from the old independence of individual day  
26   work to scientific cooperation.

27   In most cases, however, there exist certain imperfections in working  
28   conditions which can at once be improved with benefit to all concerned.

29   In this instance it was found that the inspectors (girls) were working ten  
30   and one-half hours per day (with a Saturday half holiday.)

31   Their work consisted briefly in placing a row of small polished steel balls  
32   on the back of the left hand, in the crease between two of the fingers  
33   pressed together, and while they were rolled over and over, they were  
34   minutely examined in a strong light, and with the aid of a magnet held in the  
35   right hand, the defective balls were picked out and thrown into especial  
36   boxes. Four kinds of defects were looked for -- dented, soft, scratched, and  
37   fire-cracked -- and they were mostly so minute as to be invisible to an eye  
38   not especially trained to this work. It required the closest attention and  
39   concentration, so that the nervous tension of the inspectors was  
40   considerable, in spite of the fact that they were comfortably seated and were  
41   not physically tired.

42   A most casual study made it evident that a very considerable part of the ten  
43   and one-half hours during which the girls were supposed to work was really  
44   spent in idleness because the working period was too long.

1 It is a matter of ordinary common sense to plan working hours so that the  
2 workers can really "work while they work" and "play while they play," and not  
3 mix the two.

4 Before the arrival of Mr. Sanford E. Thompson, who undertook a scientific  
5 study of the whole process, we decided, therefore, to shorten the working  
6 hours.

7 The old foreman who had been over the inspecting room for years was  
8 instructed to interview one after another of the better inspectors and the  
9 more influential girls and persuade them that they could do just as much work  
10 in ten hours each day as they had been doing in ten and one-half hours. Each  
11 girl was told that the proposition was to shorten the day's work to ten hours  
12 and pay them the same day's pay they were receiving for the ten and one-half  
13 hours.

14 In about two weeks the foreman reported that all of the girls he had talked  
15 to agreed that they could do their present work just as well in ten hours as  
16 in ten and one-half and that they approved of the change.

17 The writer had not been especially noted for his tact so he decided that it  
18 would be wise for him to display a little more of this quality by having the  
19 girls vote on the new proposition. This decision was hardly justified,  
20 however, for when the vote was taken the girls were unanimous that 10 1/2  
21 hours was good enough for them and they wanted no innovation of any kind.

22 This settled the matter for the time being. A few months later tact was  
23 thrown to the winds and the working hours were arbitrarily shortened in  
24 successive steps to 10 hours, 9 1/2, 9, and 8 1/2 (the pay per day remaining  
25 the same); and with each shortening of the working day the output increased  
26 instead of diminishing.

27 The change from the old to the scientific method in this department was made  
28 under the direction of Mr. Sanford E. Thompson, perhaps the most experienced  
29 man in motion and time study in this country, under the general  
30 superintendence of Mr. H. L. Gautt.

31 In the Physiological departments of our universities experiments are  
32 regularly conducted to determine what is known as the "personal coefficient"  
33 of the man tested. This is done by suddenly bringing some object, the letter  
34 A or B for instance, within the range of vision of the subject, who, the  
35 instant he recognizes the letter has to do some definite thing, such as to  
36 press a particular electric button. The time which elapses from the instant  
37 the letter comes in view until the subject presses the button is accurately  
38 recorded by a delicate scientific instrument.

39 This test shows conclusively that there is a great difference in the  
40 "personal coefficient" of different men. Some individuals are born with  
41 unusually quick powers of perception accompanied by quick responsive action.  
42 With some the message is almost instantly transmitted from the eye to the  
43 brain, and the brain equally quickly responds by sending the proper message  
44 to the hand.

45 Men of this type are said to have a low "personal coefficient," while those  
46 of slow perception and slow action have a *high* "personal coefficient."

1 Mr. Thompson soon recognized that the quality most needed for bicycle ball  
2 inspectors was a low "personal coefficient." Of course the ordinary qualities  
3 of endurance and industry were also called for.

4 For the ultimate good of the girls as well as the company, however, it became  
5 necessary to exclude all girls who lacked a low "personal coefficient." And  
6 unfortunately this involved laying off many of the most intelligent, hardest  
7 working, and most trustworthy girls merely because they did not possess the  
8 quality of quick perception followed by quick action.

9 While the gradual selection of girls was going on other changes were also  
10 being made.

11 One of the dangers to be guarded against, when the pay of the man or woman is  
12 made in any way to depend on the quantity of the work done, is that in the  
13 effort to increase the quantity the quality is apt to deteriorate.

14 It is necessary in almost all cases, therefore, to take definite steps to  
15 insure against any falling off in quality before moving in any way towards an  
16 increase in quantity.

17 In the work of these particular girls quality was the very essence. They were  
18 engaged in picking out all defective balls.

19 The first step, therefore, was to make it impossible for them to slight their  
20 work without being found out. This was accomplished through what is known as  
21 over-inspection Each one of four of the most trustworthy girls was given each  
22 day a lot of balls to inspect which had been examined the day before by one  
23 of the regular inspectors; the number identifying the lot to be over-  
24 inspected having been changed by the foreman so that none of the over-  
25 inspectors knew whose work they were examining. In addition to this one of  
26 the lots inspected by the four over-inspectors was examined on the following  
27 day by the chief inspector, selected on account of her especial accuracy and  
28 integrity.

29 An effective expedient was adopted for checking the honesty and accuracy of  
30 the over-inspection. Every two or three days a lot of balls was especially  
31 prepared by the foreman, who counted out a definite number of perfect balls,  
32 and added a recorded number of defective balls of each kind. Neither the  
33 inspectors nor the over-inspectors had any means of distinguishing this  
34 prepared lot from the regular commercial lots. And in this way all temptation  
35 to slight their work or make false returns was removed.

36 After insuring in this way against deterioration in quality, effective means  
37 were at once adopted to increase the output. Improved day work was  
38 substituted for the old slipshod method. An accurate daily record was kept  
39 both as to the quantity and quality of the work done in order to guard  
40 against any personal prejudice on the part of the foreman and to insure  
41 absolute impartiality and justice for each inspector. In a comparatively  
42 short time this record enabled the foreman to stir the ambition of all the  
43 inspectors by increasing the wages of those who turned out a large quantity  
44 and good quality, while at the same time lowering the pay of those who did  
45 indifferent work and discharging others who proved to be incorrigibly slow or  
46 careless. A careful examination was then made of the way in which each girl  
47 spent her time and an accurate time study was undertaken, through the use of

1 a stop-watch and record blanks, to determine how fast each kind of inspection  
2 should be done, and to establish the exact conditions under which each girl  
3 could do her quickest and best work, while at the same time guarding against  
4 giving her a task so severe that there was danger from over fatigue or  
5 exhaustion. This investigation showed that the girls spent a considerable  
6 part of their time either in partial idleness, talking and half working, or  
7 in actually doing nothing.

8 Even when the hours of labor had been shortened from 10 1/2 to 8 1/2 hours, a  
9 close observation of the girls showed that after about an hour and one-half  
10 of consecutive work they began to get nervous. They evidently needed a rest.  
11 It is wise to stop short of the point at which overstrain begins, so we  
12 arranged for them to have a ten minutes period for recreation at the end of  
13 each hour and one quarter. During these recess periods (two of ten minutes  
14 each in the morning and two in the afternoon) they were obliged to stop work  
15 and were encouraged to leave their seats and get a complete change of  
16 occupation by walking around and talking, etc.

17 In one respect no doubt some people will say that these girls were brutally  
18 treated. They were seated so far apart that they could not conveniently talk  
19 while at work.

20 Shortening their hours of labor, however, and providing so far as we knew the  
21 most favorable working conditions made it possible for them to really work  
22 steadily instead of pretending to do so.

23 And it is only after this stage in the reorganization is reached, when the  
24 girls have been properly selected and on the one hand such precautions have  
25 been taken as to guard against the possibility of over-driving them, while,  
26 on the other hand, the temptation to slight their work has been removed and  
27 the most favorable working conditions have been established, that the final  
28 step should be taken which insures them what they most want, namely, high  
29 wages, and the employers what they most want, namely, the maximum output and  
30 best quality of work, -- which means a low labor cost.

31 This step is to give each girl each day a carefully measured task which  
32 demands a full day's work from a competent operative, and also to give her a  
33 large premium or bonus whenever she accomplishes this task.

34 This was done in this case through establishing what is known as differential  
35 rate piece work.(5) Under this system the pay of each girl was increased in  
36 proportion to the quantity of her output and also still more in proportion to  
37 the accuracy of her work.

38 As will be shown later, the differential rate (the lots inspected by the  
39 over-inspectors forming the basis for the differential) resulted in a large  
40 gain in the quantity of work done and at the same time in a marked  
41 improvement in the quality.

42 Before they finally worked to the best advantage it was found to be necessary  
43 to measure the output of each girl as often as once every hour, and to send a  
44 teacher to each individual who was found to be falling behind to find what  
45 was wrong, to straighten her out, and to encourage and help her to catch up.

1 There is a general principle back of this which should be appreciated by all  
2 of those who are especially interested in the management of men. A reward, if  
3 it is to be effective in stimulating men to do their best work, must come  
4 soon after the work has been done. But few men are able to look forward for  
5 more than a week or perhaps at most a month, and work hard for a reward which  
6 they are to receive at the end of this time.

7 The average workman must be able to measure what he has accomplished and  
8 clearly see his reward at the end of each day if he is to do his best. And  
9 more elementary characters, such as the young girls inspecting bicycle balls,  
10 or children, for instance, should have proper encouragement either in the  
11 shape of personal attention from those over them or an actual reward in sight  
12 as often as once an hour.

13 This is one of the principal reasons why cooperation or "profit-sharing"  
14 either through selling stock to the employees or through dividends on wages  
15 received at the end of the year, etc., have been at the best only mildly  
16 effective in stimulating men to work hard. The nice time which they are sure  
17 to have to-day if they take things easily and go slowly proves more  
18 attractive than steady hard work with a possible reward to be shared with  
19 others six months later. A second reason for the inefficiency of profit-  
20 sharing schemes had been that no form of cooperation has yet been devised in  
21 which each individual is allowed free scope for his personal ambition.  
22 Personal ambition always has been and will remain a more powerful incentive  
23 to exertion than a desire for the general welfare. The few misplaced drones,  
24 who do the loafing and share equally in the profits, with the rest, under  
25 cooperation are sure to drag the better men down toward their level.

26 Other and formidable difficulties in the path of cooperative schemes are, the  
27 equitable division of the profits, and the fact that, while workmen are  
28 always ready to share the profits, they are neither able nor willing to share  
29 the losses. Further than this, in many cases, it is neither right nor just  
30 that they should share either the profits or the losses, since these may be  
31 due in great part to causes entirely beyond their influence or control, and  
32 to which they do not contribute.

33 To come back to the girls inspecting bicycle balls, however, the final  
34 outcome of all the changes was that *thirty-five girls did the work formerly*  
35 *done by one hundred and twenty*. And that the accuracy of the work at the  
36 higher speed was two-thirds greater than at the former slow speed.

37 The good that came to the girls was,

38 *First*. That they averaged from 80 to 100 per cent higher wages than they  
39 formerly received.

40 *Second*. Their hours of labor were shortened from 10 1/2 to 8 1/2 per day,  
41 with a Saturday half holiday. And they were given four recreation periods  
42 properly distributed through the day, which made overworking impossible for a  
43 healthy girl.

44 *Third*. Each girl was made to feel that she was the object of especial care  
45 and interest on the part of the management, and that if anything went wrong  
46 with her she could always have a helper and teacher in the management to lean  
47 upon.

1 *Fourth.* All young women should be given two consecutive days of rest (with  
2 pay) each month, to be taken whenever they may choose. It is my impression  
3 that these girls were given this privilege, although I am not quite certain  
4 on this point.

5 The benefits which came to the company from these changes were:

6 *First.* A substantial improvement in the quality of the product.

7 *Second.* A material reduction in the cost of inspection, in spite of the extra  
8 expense *involved* in clerk work, teachers, time study, over-inspectors, and in  
9 paying higher wages.

10 *Third.* That the most friendly relations existed between the management and  
11 the employees, which rendered labor troubles of any kind or a strike  
12 impossible.

13 These good results were brought about by many changes which substituted  
14 favorable for unfavorable working conditions. It should be appreciated,  
15 however, that the one element which did more than all of the others was, the  
16 careful selection of girls with quick perception to replace those whose  
17 perceptions were slow -- (the substitution of girls with a low personal  
18 coefficient for those whose personal coefficient was high) -- the scientific  
19 selection of the workers.

20 The illustrations have thus far been purposely confined to the more  
21 elementary types of work, so that a very strong doubt must still remain as to  
22 whether this kind of cooperation is desirable in the case of more intelligent  
23 mechanics, that is, in the case of men who are more capable of  
24 generalization, and who would therefore be more likely, of their own  
25 volition, to choose the more scientific and better methods. The following  
26 illustrations will be given for the purpose of demonstrating the fact that in  
27 the higher classes of work the scientific laws which are developed are so  
28 intricate that the high-priced mechanic needs (even more than the cheap  
29 laborer) the cooperation of men better educated than himself in finding the  
30 laws, and then in selecting, developing, and training him to work in  
31 accordance with these laws. These illustrations should make perfectly clear  
32 our original proposition that in practically all of the mechanic arts the  
33 science which underlies each workman's act is so great and amounts to so much  
34 that the workman who is best suited to actually doing the work is incapable,  
35 either through lack of education or through insufficient mental capacity, of  
36 understanding this science.

37 A doubt, for instance, will remain in the minds perhaps of most readers (in  
38 the case of an establishment which manufactures the same machine, year in and  
39 year out, in large quantities, and in which, therefore, each mechanic repeats  
40 the same limited series of operations over and over again), whether the  
41 ingenuity of each workman and the help which he from time to time receives  
42 from his foreman will not develop such superior methods and such a personal  
43 dexterity that no scientific study which could be made would result in a  
44 material increase in efficiency.

45 A number of years ago a company employing about three hundred men, which had  
46 been manufacturing the same machine for ten to fifteen years, sent for us to  
47 report as to whether any gain could be made through the introduction of

1 scientific management. Their shops had been run for many years under a good  
2 superintendent and with excellent foremen and workmen, on piece work. The  
3 whole establishment was, without doubt, in better physical condition than the  
4 average machine-shop in this country. The superintendent was distinctly  
5 displeased when told that through the adoption of task management the output,  
6 with the same number of men and machines, could be more than doubled. He said  
7 that he believed that any such statement was mere boasting, absolutely false,  
8 and instead of inspiring him with confidence, he was disgusted that any one  
9 should make such an impudent claim. He, however, readily assented to the  
10 proposition that he should select any one of the machines whose output he  
11 considered as representing the average of the shop, and that we should then  
12 demonstrate on this machine that through scientific methods its output could  
13 be more than doubled.

14 The machine selected by him fairly represented the work of the shop. It had  
15 been run for ten or twelve years past by a first-class mechanic who was more  
16 than equal in his ability to the average workmen in the establishment. In a  
17 shop of this sort, in which similar machines are made over and over again,  
18 the work is necessarily greatly subdivided, so that no one man works upon  
19 more than a comparatively small number of parts during the year. A careful  
20 record was therefore made, in the presence of both parties, of the time  
21 actually taken in finishing each of the parts which this man worked upon. The  
22 total time required by him to finish each piece, as well as the exact speeds  
23 and feeds which he took, were noted, and a record was kept of the time which  
24 he took in setting the work in the machine and removing it. After obtaining  
25 in this way a statement of what represented a fair average of the work done  
26 in the shop, we applied to this one machine the principles of scientific  
27 management.

28 By means of four quite elaborate slide-rules, which have been especially made  
29 for the purpose of determining the all-round capacity of metal-cutting  
30 machines, a careful analysis was made of every element of this machine in its  
31 relation to the work in hand. Its pulling power at its various speeds, its  
32 feeding capacity, and its proper speeds were determined by means of the  
33 slide-rules, and changes were then made in the countershaft and driving  
34 pulleys so as to run it at its proper speed. Tools, made of high-speed steel,  
35 and of the proper shapes, were properly dressed, treated, and ground. (It  
36 should be understood, however, that in this case the high-speed steel which  
37 had heretofore been in general use in the shop was also used in our  
38 demonstration.) A large special slide-rule was then made, by means of which  
39 the exact speeds and feeds were indicated at which each kind of work could be  
40 done in the shortest possible time in this particular lathe. After preparing  
41 in this way so that the workman should work according to the new method, one  
42 after another, pieces of work were finished in the lathe, corresponding to  
43 the work which had been done in our preliminary trials, and the gain in time  
44 made through running the machine according to scientific principles ranged  
45 from two and one-half times the speed in the slowest instance to nine times  
46 the speed in the highest.

47 The change from rule-of-thumb management to scientific management involves,  
48 however, not only a study of what is the proper speed for doing the work and  
49 a remodeling of the tools and the implements in the shop, but also a complete  
50 change in the mental attitude of all the men in the shop toward their work  
51 and toward their employers. The physical improvements in the machines  
52 necessary to insure large gains, and the motion study followed by minute  
53 study with a stop-watch of the time in which each workman should do his work,

1 can be made comparatively quickly. But the change in the mental attitude and  
2 in the habits of the three hundred or more workmen can be brought about only  
3 slowly and through a long series of object-lessons, which finally  
4 demonstrates to each man the great advantage which he will gain by heartily  
5 cooperating in his every-day work with the men in the management. Within  
6 three years, however, in this shop, the output had been more than doubled per  
7 man and per machine. The men had been carefully selected and in almost all  
8 cases promoted from a lower to a higher order of work, and so instructed by  
9 their teachers (the functional foremen) that they were able to earn higher  
10 wages than ever before. The average increase in the daily earnings of each  
11 man was about 35 per cent, while, at the same time, the sum total of the  
12 wages paid for doing a given amount of work was lower than before. This  
13 increase in the speed of doing the work, of course, involved a substitution  
14 of the quickest hand methods for the old independent rule-of-thumb methods,  
15 and an elaborate analysis of the hand work done by each man. (By hand work is  
16 meant such work as depends upon the manual dexterity and speed of a workman,  
17 and which is independent of the work done by the machine.) The time saved by  
18 scientific hand work was in many cases greater even than that saved in  
19 machine-work.

20 It seems important to fully explain the reason why, with the aid of a slide-  
21 rule, and after having studied the art of cutting metals, it was possible for  
22 the scientifically equipped man, who had never before seen these particular  
23 jobs, and who had never worked on this machine, to do work from two and one-  
24 half to nine times as fast as it had been done before by a good mechanic who  
25 had spent his whole time for some ten to twelve years in doing this very work  
26 upon this particular machine. In a word, this was possible because the art of  
27 cutting metals involves a true science of no small magnitude, a science, in  
28 fact, so intricate that it is impossible for any machinist who is suited to  
29 running a lathe year in and year out either to understand it or to work  
30 according to its laws without the help of men who have made this their  
31 specialty. Men who are unfamiliar with machine-shop work are prone to look  
32 upon the manufacture of each piece as a special problem, independent of any  
33 other kind of machine-work. They are apt to think, for instance, that the  
34 problems connected with making the parts of an engine require the especial  
35 study, one may say almost the life study, of a set of engine-making  
36 mechanics, and that these problems are entirely different from those which  
37 would be met with in machining lathe or planer parts. In fact, however, a  
38 study of those elements which are peculiar either to engine parts or to lathe  
39 parts is trifling, compared with the great study of the art, or science, of  
40 cutting metals, upon a knowledge of which rests the ability to do really fast  
41 machine-work of all kinds.

42 The real problem is how to remove chips fast from a casting or a forging, and  
43 how to make the piece smooth and true in the shortest time, and it matters  
44 but little whether the piece being worked upon is part, say, of a marine  
45 engine, a printing-press, or an automobile. For this reason, the man with the  
46 slide-rule, familiar with the science of cutting metals, who had never before  
47 seen this particular work, was able completely to distance the skilled  
48 mechanic who had made the parts of this machine his specialty for years.

49 It is true that whenever intelligent and educated men find that the  
50 responsibility for making progress in any of the mechanic arts rests with  
51 them, instead of upon the workmen who are actually laboring at the trade,  
52 then they almost invariably start on the road which leads to the development  
53 of a science where, in the past, has existed mere traditional or rule-of-

thumb knowledge. When men, whose education has given them the habit of generalizing and everywhere looking for laws, find themselves confronted with a multitude of problems, such as exist in every trade and which have a general similarity one to another, it is inevitable that they should try to gather these problems into certain logical groups, and then search for some general laws or rules to guide them in their solution. As has been pointed out, however, the underlying principles of the management of "initiative and incentive," that is, the underlying philosophy of this management, necessarily leaves the solution of all of these problems in the hands of each individual workman, while the philosophy of scientific management places their solution in the hands of the management. The workman's whole time is each day taken in actually doing the work with his hands, so that, even if he had the necessary education and habits of generalizing in his thought, he lacks the time and the opportunity for developing these laws, because the study of even a simple law involving say time study requires the cooperation of two men, the one doing the work while the other times him with a stop-watch. And even if the workman were to develop laws where before existed only rule-of-thumb knowledge, his personal interest would lead him almost inevitably to keep his discoveries secret, so that he could, by means of this special knowledge, personally do more work than other men and so obtain higher wages.

Under scientific management, on the other hand, it becomes the duty and also the pleasure of those who are engaged in the management not only to develop laws to replace rule of thumb, but also to teach impartially all of the workmen who are under them the quickest ways of working. The useful results obtained from these laws are always so great that any company can well afford to pay for the time and the experiments needed to develop them. Thus under scientific management exact scientific knowledge and methods are everywhere, sooner or later, sure to replace rule of thumb, whereas under the old type of management working in accordance with scientific laws is an impossibility.

The development of the art or science of cutting metals is an apt illustration of this fact. In the fall of 1880, about the time that the writer started to make the experiments above referred to, to determine what constitutes a proper day's work for a laborer, he also obtained the permission of Mr. William Sellers, the President of the Midvale Steel Company, to make a series of experiments to determine what angles and shapes of tools were the best for cutting steel, and also to try to determine the proper cutting speed for steel. At the time that these experiments were started it was his belief that they would not last longer than six months, and, in fact, if it had been known that a longer period than this would be required, the permission to spend a considerable sum of money in making them would not have been forthcoming.

A 66-inch diameter vertical boring-mill was the first machine used in making these experiments, and large locomotive tires, made out of hard steel of uniform quality, were day after day cut up into chips in gradually learning how to make, shape, and use the cutting tools so that they would do faster work. At the end of six months sufficient practical information had been obtained to far more than repay the cost of materials and wages which had been expended in experimenting. And yet the comparatively small number of experiments which had been made served principally to make it clear that the actual knowledge attained was but a small fraction of that which still remained to be developed, and which was badly needed by us, in our daily attempt to direct and help the machinists in their tasks.

1 Experiments in this field were carried on, with occasional interruption,  
2 through a period of about 26 years, in the course of which ten different  
3 experimental machines were especially fitted up to do this work. Between  
4 30,000 and 50,000 experiments were carefully recorded, and many other  
5 experiments were made, of which no record was kept. In studying these laws  
6 more than 800,000 pounds of steel and iron was cut up into chips with the  
7 experimental tools, and it is estimated that from \$150,000 to \$200,000 was  
8 spent in the investigation.

9 Work of this character is intensely interesting to any one who has any love  
10 for scientific research. For the purpose of this paper, however, it should be  
11 fully appreciated that the motive power which kept these experiments going  
12 through many years, and which supplied the money and the opportunity for  
13 their accomplishment, was not an abstract search after scientific knowledge,  
14 but was the very practical fact that we lacked the exact information which  
15 was needed every day, in order to help our machinists to do their work in the  
16 best way and in the quickest time.

17 All of these experiments were made to enable us to answer correctly the two  
18 questions which face every machinist each time that he does a piece of work  
19 in a metal-cutting machine, such as a lathe, planer, drill press, or milling  
20 machine. These two questions are: In order to do the work in the quickest  
21 time, At what cutting speed shall I run my machine? And What feed shall I  
22 use?

23 They sound so simple that they would appear to call for merely the trained  
24 judgment of any good mechanic. In fact, however, after working 26 years, it  
25 has been found that the answer in every case involves the solution of an  
26 intricate mathematical problem, in which the effect of twelve independent  
27 variables must be determined.

28 Each of the twelve following variables has an important effect upon the  
29 answer. The figures which are given with each of the variables represent the  
30 effect of this element upon the cutting speed. For example, after the first  
31 variable (A) we quote, "The proportion is as 1 in the case of semi-hardened  
32 steel or chilled iron to 100 in the case of a very soft, low-carbon steel."  
33 The meaning of this quotation is that soft steel can be cut 100 times as fast  
34 as the hard steel or chilled iron. The ratios which are given, then, after  
35 each of these elements, indicate the wide range of judgment which practically  
36 every machinist has been called upon to exercise in the past in determining  
37 the best speed at which to run the machine and the best feed to use.

38 (A) The quality of the metal which is to be cut; i.e., its hardness or other  
39 qualities which affect the cutting speed. The proportion is as 1 in the case  
40 of semi-hardened steel or chilled iron to 100 in the case of very soft, low-  
41 carbon steel.

42 (B) The chemical composition of the steel from which the tool is made, and  
43 the heat treatment of the tool. The proportion is as 1 in tools made from  
44 tempered carbon steel to 7 in the best high-speed tools.

45 (C) The thickness of the shaving, or, the thickness of the spiral strip or  
46 band of metal which is to be removed by the tool. The proportion is as 1 with  
47 thickness of shaving  $\frac{3}{16}$  of an inch to  $3\frac{1}{2}$  with thickness of shaving  $\frac{1}{64}$   
48 of an inch.

- (D) The shape or contour of the cutting edge of the tool. The proportion is as 1 in a thread tool to 6 in a broad-nosed cutting tool.
- (E) Whether a copious stream of water or other cooling medium is used on the tool. The proportion is as 1 for tool running dry to 1.41 for tool cooled by a copious stream of water.
- (F) The depth of the cut. The proportion is as 1 with 1/2-inch depth of cut to 1.36 with 1/8-inch depth of cut.
- (G) The duration of the cut, i.e., the time which a tool must last under pressure of the shaving without being reground. The proportion is as 1 when tool is to be ground every 1 1/2 hours to 1.20 when tool is to be ground every 20 minutes.
- (H) The lip and clearance angles of the tool. The proportion is as 1 with lip angle of 68 degrees to 1.023 with lip angle of 61 degrees.
- (J) The elasticity of the work and of the tool on account of producing chatter. The proportion is as 1 with tool chattering to 1.15 with tool running smoothly.
- (K) The diameter of the casting or forging which is being cut.
- (L) The pressure of the chip or shaving upon the cutting surface of the tool.
- (M) The pulling power and the speed and feed changes of the machine.

It may seem preposterous to many people that it should have required a period of 26 years to investigate the effect of these twelve variables upon the cutting speed of metals. To those, however, who have had personal experience as experimenters, it will be appreciated that the great difficulty of the problem lies in the fact that it contains so many variable elements. And in fact the great length of time consumed in making each single experiment was caused by the difficulty of holding eleven variables constant and uniform throughout the experiment, while the effect of the twelfth variable was being investigated. Holding the eleven variables constant was far more difficult than the investigation of the twelfth element.

As, one after another, the effect upon the cutting speed of each of these variables was investigated, in order that practical use could be made of this knowledge, it was necessary to find a mathematical formula which expressed in concise form the laws which had been obtained. As examples of the twelve formulæ which were developed, the three following are given:

$$P = 45,000D^{14/15}F^{3/4}$$

$$V = 90/T^{1/8}$$

$$V = 11.9/F^{0.665}((48/3)*D)^{0.2373 + (2.4/(18 + 24D))}$$

After these laws had been investigated and the various formulæ which mathematically expressed them had been determined, there still remained the

1 difficult task of how to solve one of these complicated mathematical problems  
2 quickly enough to make this knowledge available for every-day use. If a good  
3 mathematician who had these formulæ before him were to attempt to get the  
4 proper answer (i.e., to get the correct cutting speed and feed by working in  
5 the ordinary way) it would take him from two to six hours, say, to solve a  
6 single problem; far longer to solve the mathematical problem than would be  
7 taken in most cases by the workmen in doing the whole job in his machine.  
8 Thus a task of considerable magnitude which faced us was that of finding a  
9 quick solution of this problem, and as we made progress in its solution, the  
10 whole problem was from time to time presented by the writer to one after  
11 another of the noted mathematicians in this country. They were offered any  
12 reasonable fee for a rapid, practical method to be used in its solution. Some  
13 of these men merely glanced at it; others, for the sake of being courteous,  
14 kept it before them for some two or three weeks. They all gave us practically  
15 the same answer: that in many cases it was possible to solve mathematical  
16 problems which contained four variables, and in some cases problems with five  
17 or six variables, but that it was manifestly impossible to solve a problem  
18 containing twelve variables in any other way than by the slow process of  
19 "trial and error."

20 A quick solution was, however, so much of a necessity in our every-day work  
21 of running machine-shops, that in spite of the small encouragement received  
22 from the mathematicians, we continued at irregular periods, through a term of  
23 fifteen years, to give a large amount of time searching for a simple  
24 solution. Four or five men at various periods gave practically their whole  
25 time to this work, and finally, while we were at the Bethlehem Steel Company,  
26 the slide-rule was developed which is illustrated on Folder No.11 of the  
27 paper "On the Art of Cutting Metals," and is described in detail in the paper  
28 presented by Mr. Carl G. Barth to the American Society of Mechanical  
29 Engineers, entitled "Slide-rules for the Machine-shop, as a part of the  
30 Taylor System of Management" (Vol. XXV of The Transactions of the American  
31 Society of Mechanical Engineers). By means of this slide-rule, one of these  
32 intricate problems can be solved in less than a half minute by any good  
33 mechanic, whether he understands anything about mathematics or not, thus  
34 making available for every-day, practical use the years of experimenting on  
35 the art of cutting metals.

36 This is a good illustration of the fact that some way can always be found of  
37 making practical, everyday use of complicated scientific data, which appears  
38 to be beyond the experience and the range of the technical training of  
39 ordinary practical men. These slide-rules have been for years in constant  
40 daily use by machinists having no knowledge of mathematics.

41 A glance at the intricate mathematical formulæ (see page 109) which represent  
42 the laws of cutting metals should clearly show the reason why it is  
43 impossible for any machinist, without the aid of these laws, and who depends  
44 upon his personal experience, correctly to guess at the answer to the two  
45 questions, What speed shall I use? What feed shall I use? even though he may  
46 repeat the same piece of work many times.

47 To return to the case of the machinist who had been working for ten to twelve  
48 years in machining the same pieces over and over again, there was but a  
49 remote chance in any of the various kinds of work which this man did that he  
50 should hit upon the one best method of doing each piece of work out of the  
51 hundreds of possible methods which lay before him. In considering this  
52 typical case, it must also be remembered that the metal-cutting machines

1 throughout our machine-shops have practically all been speeded by their  
2 makers by guesswork, and without the knowledge obtained through a study of  
3 the art of cutting metals. In the machine-shops systematized by us we have  
4 found that there is not one machine in a hundred which is speeded by its  
5 makers at anywhere near the correct cutting speed. So that, in order to  
6 compete with the science of cutting metals, the machinist, before he could  
7 use proper speeds, would first have to put new pulleys on the countershaft of  
8 his machine, and also make in most cases changes in the shapes and treatment  
9 of his tools, etc. Many of these changes are matters entirely beyond his  
10 control, even if he knows what ought to be done.

11 If the reason is clear to the reader why the rule-of-thumb knowledge obtained  
12 by the machinist who is engaged on repeat work cannot possibly compete with  
13 the true science of cutting metals, it should be even more apparent why the  
14 high-class mechanic, who is called upon to do a great variety of work from  
15 day to day, is even less able to compete with this science. The high-class  
16 mechanic who does a different kind of work each day, in order to do each job  
17 in the quickest time, would need, in addition to a thorough knowledge of the  
18 art of cutting metals, a vast knowledge and experience in the quickest way of  
19 doing each kind of hand work. And the reader, by calling to mind the gain  
20 which was made by Mr. Gilbreth through his motion and time study in laying  
21 bricks, will appreciate the great possibilities for quicker methods of doing  
22 all kinds of hand work which lie before every tradesman after he has the help  
23 which comes from a scientific motion and time study of his work.

24 For nearly thirty years past, time-study men connected with the management of  
25 machine-shops have been devoting their whole time to a scientific motion  
26 study, followed by accurate time study, with a stop-watch, of all of the  
27 elements connected with the machinist's work. When, therefore, the teachers,  
28 who form one section of the management, and who are cooperating with the  
29 working men, are in possession both of the science of cutting metals and of  
30 the equally elaborate motion-study and time-study science connected with this  
31 work, it is not difficult to appreciate why even the highest class mechanic  
32 is unable to do his best work without constant daily assistance from his  
33 teachers. And if this fact has been made clear to the reader, one of the  
34 important objects in writing this paper will have been realized.

35 It is hoped that the illustrations which have been given make it apparent why  
36 scientific management must inevitably in all cases produce overwhelmingly  
37 greater results, both for the company and its employees, than can be obtained  
38 with the management of "initiative and incentive." And it should also be  
39 clear that these results have been attained, not through a marked superiority  
40 in the mechanism of one type of management over the mechanism of another, but  
41 rather through the substitution of one set of underlying principles for a  
42 totally different set of principles, by the substitution of one philosophy  
43 for another philosophy in industrial management.

44 To repeat then throughout all of these illustrations, it will be seen that  
45 the useful results have hinged mainly upon (1) the substitution of a science  
46 for the individual judgment of the workman; (2) the scientific selection and  
47 development of the workman, after each man has been studied, taught, and  
48 trained, and one may say experimented with, instead of allowing the workmen  
49 to select themselves and develop in a haphazard way; and (3) the intimate  
50 cooperation of the management with the workmen, so that they together do the  
51 work in accordance with the scientific laws which have been developed,  
52 instead of leaving the solution of each problem in the hands of the

1 individual workman. In applying these new principles, in place of the old  
2 individual effort of each workman, both sides share almost equally in the  
3 daily performance of each task, the management doing that part of the work  
4 for which they are best fitted, and the workmen the balance.

5 It is for the illustration of this philosophy that this paper has been  
6 written, but some of the elements involved in its general principles should  
7 be further discussed.

8 The development of a science sounds like a formidable undertaking, and in  
9 fact anything like a thorough study of a science such as that of cutting  
10 metals necessarily involves many years of work. The science of cutting  
11 metals, however, represents in its complication, and in the time required to  
12 develop it, almost an extreme case in the mechanic arts. Yet even in this  
13 very intricate science, within a few months after starting, enough knowledge  
14 had been obtained to much more than pay for the work of experimenting. This  
15 holds true in the case of practically all scientific development in the  
16 mechanic arts. The first laws developed for cutting metals were crude, and  
17 contained only a partial knowledge of the truth, yet this imperfect knowledge  
18 was vastly better than the utter lack of exact information or the very  
19 imperfect rule of thumb which existed before, and it enabled the workmen,  
20 with the help of the management, to do far quicker and better work.

21 For example, a very short time was needed to discover one or two types of  
22 tools which, though imperfect as compared with the shapes developed years  
23 afterward, were superior to all other shapes and kinds in common use. These  
24 tools were adopted as standard and made possible an immediate increase in the  
25 speed of every machinist who used them. These types were superseded in a  
26 comparatively short time by still other tools which remained standard until  
27 they in their turn made way for later improvements.(6)

28 The science which exists in most of the mechanic arts is, however, far  
29 simpler than the science of cutting metals. In almost all cases, in fact, the  
30 laws or rules which are developed are so simple that the average man would  
31 hardly dignify them with the name of a science. In most trades, the science  
32 is developed through a comparatively simple analysis and time study of the  
33 movements required by the workmen to do some small part of his work, and this  
34 study is usually made by a man equipped merely with a stop-watch and a  
35 properly ruled notebook. Hundreds of these "time-study men" are now engaged  
36 in developing elementary scientific knowledge where before existed only rule  
37 of thumb. Even the motion study of Mr. Gilbreth in bricklaying (described on  
38 pages 77 to 84) involves a much more elaborate investigation than that which  
39 occurs in most cases. The general steps to be taken in developing a simple  
40 law of this class are as follows:

41 *First.* Find, say, 10 or 15 different men (preferably in as many separate  
42 establishments and different parts of the country) who are especially skilful  
43 in doing the particular work to be analyzed.

44 *Second.* Study the exact series of elementary operations or motions which each  
45 of these men uses in doing the work which is being investigated, as well as  
46 the implements each man uses.

1 *Third.* Study with a stop-watch the time required to make each of these  
2 elementary movements and then select the quickest way of doing each element  
3 of the work.

4 *Fourth.* Eliminate all false movements, slow movements, and useless movements.

5 *Fifth.* After doing away with all unnecessary movements, collect into one  
6 series the quickest and best movements as well as the best implements.

7 This one new method, involving that series of motions which can be made  
8 quickest and best, is then substituted in place of the ten or fifteen  
9 inferior series which were formerly in use. This best method becomes  
10 standard, and remains standard, to be taught first to the teachers (or  
11 functional foremen) and by them to every workman in the establishment until  
12 it is superseded by a quicker and better series of movements. In this simple  
13 way one element after another of the science is developed.

14 In the same way each type of implement used in a trade is studied. Under the  
15 philosophy of the management of "initiative and incentive" each workman is  
16 called upon to use his own best judgment, so as to do the work in the  
17 quickest time, and from this results in all cases a large variety in the  
18 shapes and types of implements which are used for any specific purpose.  
19 Scientific management requires, first, a careful investigation of each of the  
20 many modifications of the same implement, developed under rule of thumb; and  
21 second, after a time study has been made of the speed attainable with each of  
22 these implements, that the good points of several of them shall be united in  
23 a single standard implement, which will enable the workman to work faster and  
24 with greater ease than he could before. This one implement, then, is adopted  
25 as standard in place of the many different kinds before in use, and it  
26 remains standard for all workmen to use until superseded by an implement  
27 which has been shown, through motion and time study, to be still better.

28 With this explanation it will be seen that the development of a science to  
29 replace rule of thumb is in most cases by no means a formidable undertaking,  
30 and that it can be accomplished by ordinary, every-day men without any  
31 elaborate scientific training; but that, on the other hand, the successful  
32 use of even the simplest improvement of this kind calls for records, system,  
33 and cooperation where in the past existed only individual effort.

34 There is another type of scientific investigation which has been referred to  
35 several times in this paper, and which should receive special attention,  
36 namely, the accurate study of the motives which influence men. At first it  
37 may appear that this is a matter for individual observation and judgment, and  
38 is not a proper subject for exact scientific experiments. It is true that the  
39 laws which result from experiments of this class, owing to the fact that the  
40 very complex organism-the human being is being experimented with, are subject  
41 to a larger number of exceptions than is the case with laws relating to  
42 material things. And yet laws of this kind, which apply to a large majority  
43 of men, unquestionably exist, and when clearly defined are of great value as  
44 a guide in dealing with men. In developing these laws, accurate, carefully  
45 planned and executed experiments, extending through a term of years, have  
46 been made, similar in a general way to the experiments upon various other  
47 elements which have been referred to in this paper.

1 Perhaps the most important law belonging to this class, in its relation to  
2 scientific management, is the effect which the task idea has upon the  
3 efficiency of the workman. This, in fact, has become such an important  
4 element of the mechanism of scientific management, that by a great number of  
5 people scientific management has come to be known as "task management."

6 There is absolutely nothing new in the task idea. Each one of us will  
7 remember that in his own case this idea was applied with good results in his  
8 schoolboy days. No efficient teacher would think of giving a class of  
9 students an indefinite lesson to learn. Each day a definite, clear-cut task  
10 is set by the teacher before each scholar, stating that he must learn just so  
11 much of the subject; and it is only by this means that proper, systematic  
12 progress can be made by the students. The average boy would go very slowly  
13 if, instead of being given a task, he were told to do as much as he could.  
14 All of us are grown-up children, and it is equally true that the average  
15 workman will work with the greatest satisfaction, both to himself and to his  
16 employer, when he is given each day a definite task which he is to perform in  
17 a given time, and which constitutes a proper day's work for a good workman.  
18 This furnishes the workman with a clear-cut standard, by which he can  
19 throughout the day measure his own progress, and the accomplishment of which  
20 affords him the greatest satisfaction.

21 The writer has described in other papers a series of experiments made upon  
22 workmen, which have resulted in demonstrating the fact that it is impossible,  
23 through any long period of time, to get workmen to work much harder than the  
24 average men around them, unless they are assured a large and a permanent  
25 increase in their pay. This series of experiments, however, also proved that  
26 plenty of workmen can be found who are willing to work at their best speed,  
27 provided they are given this liberal increase in wages. The workman must,  
28 however, be fully assured that this increase beyond the average is to be  
29 permanent. Our experiments have shown that the exact percentage of increase  
30 required to make a workman work at his highest speed depends upon the kind of  
31 work which the man is doing.

32 It is absolutely necessary, then, when workmen are daily given a task which  
33 calls for a high rate of speed on their part, that they should also be  
34 insured the necessary high rate of pay whenever they are successful. This  
35 involves not only fixing for each man his daily task, but also paying him a  
36 large bonus, or premium, each time that he succeeds in doing his task in the  
37 given time. It is difficult to appreciate in full measure the help which the  
38 proper use of these two elements is to the workman in elevating him to the  
39 highest standard of efficiency and speed in his trade, and then keeping him  
40 there, unless one has seen first the old plan and afterward the new tried  
41 upon the same man. And in fact until one has seen similar accurate  
42 experiments made upon various grades of workmen engaged in doing widely  
43 different types of work. The remarkable and almost uniformly good results  
44 from the correct application of the task and the bonus must be seen to be  
45 appreciated.

46 These two elements, the task and the bonus (which, as has been pointed out in  
47 previous papers, can be applied in several ways), constitute two of the most  
48 important elements of the mechanism of scientific management. They are  
49 especially important from the fact that they are, as it were, a climax,  
50 demanding before they can be used almost all of the other elements of the  
51 mechanism; such as a planning department, accurate time study,  
52 standardization of methods and implements, a routing system, the training of

1 functional foremen or teachers, and in many cases instruction cards, slide-  
2 rules, etc. (Referred to later in rather more detail on page 129.)

3 The necessity for systematically teaching workmen how to work to the best  
4 advantage has been several times referred to. It seems desirable, therefore,  
5 to explain in rather more detail how this teaching is done. In the case of a  
6 machine-shop which is managed under the modern system, detailed written  
7 instructions as to the best way of doing each piece of work are prepared in  
8 advance, by men in the planning department. These instructions represent the  
9 combined work of several men in the planning room, each of whom has his own  
10 specialty, or function. One of them, for instance, is a specialist on the  
11 proper speeds and cutting tools to be used. He uses the slide-rules which  
12 have been above described as an aid, to guide him in obtaining proper speeds,  
13 etc. Another man analyzes the best and quickest motions to be made by the  
14 workman in setting the work up in the machine and removing it, etc. Still a  
15 third, through the time-study records which have been accumulated, makes out  
16 a timetable giving the proper speed for doing each element of the work. The  
17 directions of all of these men, however, are written on a single instruction  
18 card, or sheet.

19 These men of necessity spend most of their time in the planning department,  
20 because they must be close to the records and data which they continually use  
21 in their work, and because this work requires the use of a desk and freedom  
22 from interruption. Human nature is such, however, that many of the workmen,  
23 if left to themselves, would pay but little attention to their written  
24 instructions. It is necessary, therefore, to provide teachers (called  
25 functional foremen) to see that the workmen both understand and carry out  
26 these written instructions.

27 Under functional management, the old-fashioned single foreman is superseded  
28 by eight different men, each one of whom has his own special duties, and  
29 these men, acting as the agents for the planning department (see paragraph  
30 234 to 245 of the paper entitled "Shop Management"), are the expert teachers,  
31 who are at all times in the shop, helping and directing the workmen. Being  
32 each one chosen for his knowledge and personal skill in his specialty, they  
33 are able not only to tell the workman what he should do, but in case of  
34 necessity they do the work themselves in the presence of the workman, so as  
35 to show him not only the best but also the quickest methods.

36 One of these teachers (called the inspector) sees to it that he understands  
37 the drawings and instructions for doing the work. He teaches him how to do  
38 work of the right quality; how to make it fine and exact where it should be  
39 fine, and rough and quick where accuracy is not required, the one being just  
40 as important for success as the other. The second teacher (the gang boss)  
41 shows him how to set up the job in his machine, and teaches him to make all  
42 of his personal motions in the quickest and best way. The third (the speed  
43 boss) sees that the machine is run at the best speed and that the proper tool  
44 is used in the particular way which will enable the machine to finish its  
45 product in the shortest possible time. In addition to the assistance given by  
46 these teachers, the workman receives orders and help from four other men;  
47 from the "repair boss" as to the adjustment, cleanliness, and general care of  
48 his machine, belting, etc.; from the "time clerk," as to everything relating  
49 to his pay and to proper written reports and returns; from the "route clerk,"  
50 as to the order in which he does his work and as to the movement of the work  
51 from one part of the shop to another; and, in case a workman gets into any  
52 trouble with any of his various bosses, the "disciplinarian" interviews him.

1 It must be understood, of course, that all workmen engaged on the same kind  
2 of work do not require the same amount of individual teaching and attention  
3 from the functional foremen. The men who are new at a given operation  
4 naturally require far more teaching and watching than those who have been a  
5 long time at the same kind of jobs.

6 Now, when through all of this teaching and this minute instruction the work  
7 is apparently made so smooth and easy for the workman, the first impression  
8 is that this all tends to make him a mere automaton, a wooden man. As the  
9 workmen frequently say when they first come under this system, "Why, I am not  
10 allowed to think or move without some one interfering or doing it for me!"  
11 The same criticism and objection, however, can be raised against all other  
12 modern subdivision of labor. It does not follow, for example, that the modern  
13 surgeon is any more narrow or wooden a man than the early settler of this  
14 country. The frontiersman, however, had to be not only a surgeon, but also an  
15 architect, house builder, lumberman, farmer, soldier, and doctor, and he had  
16 to settle his law cases with a gun. You would hardly say that the life of the  
17 modern surgeon is any more narrowing, or that he is more of a wooden man than  
18 the frontiersman. The many problems to be met and solved by the surgeon are  
19 just as intricate and difficult and as developing and broadening in their way  
20 as were those of the frontiersman.

21 And it should be remembered that the training of the surgeon has been almost  
22 identical in type with the teaching and training which is given to the  
23 workman under scientific management. The surgeon, all through his early  
24 years, is under the closest supervision of more experienced men, who show him  
25 in the minutest way how each element of his work is best done. They provide  
26 him with the finest implements, each one of which has been the subject of  
27 special study and development, and then insist upon his using each of these  
28 implements in the very best way. All of this teaching, however, in no way  
29 narrows him. On the contrary, he is quickly given the very best knowledge of  
30 his predecessors; and, provided (as he is, right from the start) with  
31 standard implements and methods which represent the best knowledge of the  
32 world up to date, he is able to use his own originality and ingenuity to make  
33 real additions to the world's knowledge, instead of reinventing things which  
34 are old. In a similar way the workman who is cooperating with his many  
35 teachers under scientific management has an opportunity to develop which is  
36 at least as good as and generally better than that which he had when the  
37 whole problem was "up to him" and he did his work entirely unaided.

38 If it were true that the workman would develop into a larger and finer man  
39 without all of this teaching, and without the help of the laws which have  
40 been formulated for doing his particular job, then it would follow that the  
41 young man who now comes to college to have the help of a teacher in  
42 mathematics, physics, chemistry, Latin, Greek, etc., would do better to study  
43 these things unaided and by himself. The only difference in the two cases is  
44 that students come to their teachers, while from the nature of the work done  
45 by the mechanic under scientific management, the teachers must go to him.  
46 What really happens is that, with the aid of the science which is invariably  
47 developed, and through the instructions from his teachers, each workman of a  
48 given intellectual capacity is enabled to do a much higher, more interesting,  
49 and finally more developing and more profitable kind of work than he was  
50 before able to do. The laborer who before was unable to do anything beyond,  
51 perhaps, shoveling and wheeling dirt from place to place, or carrying the  
52 work from one part of the shop to another, is in many cases taught to do the  
53 more elementary machinist's work, accompanied by the agreeable surroundings

1 and the interesting variety and higher wages which go with the machinist's  
2 trade. The cheap machinist or helper, who before was able to run perhaps  
3 merely a drill press, is taught to do the more intricate and higher priced  
4 lathe and planer work, while the highly skilled and more intelligent  
5 machinists become functional foremen and teachers. And so on, right up the  
6 line.

7 It may seem that with scientific management there is not the same incentive  
8 for the workman to use his ingenuity in devising new and better methods of  
9 doing the work, as well as in improving his implements, that there is with  
10 the old type of management. It is true that with scientific management the  
11 workman is not allowed to use whatever implements and methods he sees fit in  
12 the daily practise of his work. Every encouragement, however, should be given  
13 him to suggest improvements, both in methods and in implements. And whenever  
14 a workman proposes an improvement, it should be the policy of the management  
15 to make a careful analysis of the new method, and if necessary conduct a  
16 series of experiments to determine accurately the relative merit of the new  
17 suggestion and of the old standard, And whenever the new method is found to  
18 be markedly superior to the old, it should be adopted as the standard for the  
19 whole establishment. The workman should be given the full credit for the  
20 improvement, and should be paid a cash premium as a reward for his ingenuity.  
21 In this way the true initiative of the workmen is better attained under  
22 scientific management than under the old individual plan.

23 The history of the development of scientific management up to date, however,  
24 calls for a word of warning. The mechanism of management must not be mistaken  
25 for its essence, or underlying philosophy. Precisely the same mechanism will  
26 in one case produce disastrous results and in another the most beneficent.  
27 The same mechanism which will produce the finest results when made to serve  
28 the underlying principles of scientific management, will lead to failure and  
29 disaster if accompanied by the wrong spirit in those who are using it.  
30 Hundreds of people have already mistaken the mechanism of this system for its  
31 essence. Messrs Gantt, Barth, and the writer have presented papers to the  
32 American Society of Mechanical Engineers on the subject of scientific  
33 management. In these papers the mechanism which is used has been described at  
34 some length. As elements of this mechanism may be cited:

35 Time study, with the implements and methods for properly making it.

36 Functional or divided foremanship and its superiority to the old-fashioned  
37 single foreman.

38 The standardization of all tools and implements used in the trades, and also  
39 of the acts or movements of workmen for each class of work.

40 The desirability of a planning room or department.

41 The "exception principle" in management.

42 The use of slide-rules and similar time-saving implements.

43 Instruction cards for the workman.

1 The task idea in management, accompanied by a large bonus for the successful  
2 performance of the task.

3 The "differential rate."

4 Mnemonic systems for classifying manufactured products as well as implements  
5 used in manufacturing.

6 A routing system.

7 Modern cost system, etc., etc.

8 These are, however, merely the elements or details of the mechanism of  
9 management. Scientific management, in its essence, consists of a certain  
10 philosophy, which results, as before stated, in a combination of the four  
11 great underlying principles of management:(7)

12 When, however, the elements of this mechanism, such as time study, functional  
13 foremanship, etc., are used without being accompanied by the true philosophy  
14 of management, the results are in many cases disastrous. And, unfortunately,  
15 even when men who are thoroughly in sympathy with the principles of  
16 scientific management undertake to change too rapidly from the old type to  
17 the new, without heeding the warnings of those who have had years of  
18 experience in making this change, they frequently meet with serious troubles,  
19 and sometimes with strikes, followed by failure.

20 The writer, in his paper on "Shop Management," has called especial attention  
21 to the risks which managers run in attempting to change rapidly from the old  
22 to the new management. In many cases, however, this warning has not been  
23 heeded. The physical changes which are needed, the actual time study which  
24 has to be made, the standardization of all implements connected with the  
25 work, the necessity for individually studying each machine and placing it in  
26 perfect order, all take time, but the faster these elements of the work are  
27 studied and improved, the better for the undertaking. On the other hand, the  
28 really great problem involved in a change from the management of "initiative  
29 and incentive" to scientific management consists in a complete revolution in  
30 the mental attitude and the habits of all of those engaged in the management,  
31 as well of the workmen. And this change can be brought about only gradually  
32 and through the presentation of many object-lessons to the workman, which,  
33 together with the teaching which he receives, thoroughly convince him of the  
34 superiority of the new over the old way of doing the work. This change in the  
35 mental attitude of the workman imperatively demands time. It is impossible to  
36 hurry it beyond a certain speed. The writer has over and over again warned  
37 those who contemplated making this change that it was a matter, even in a  
38 simple establishment, of from two to three years, and that in some cases it  
39 requires from four to five years.

40 The first few changes which affect the workmen should be made exceedingly  
41 slowly, and only one workman at a time should be dealt with at the start.  
42 Until this single man has been thoroughly convinced that a great gain has  
43 come to him from the new method, no further change should be made. Then one  
44 man after another should be tactfully changed over. After passing the point  
45 at which from one-fourth to one-third of the men in the employ of the company  
46 have been changed from the old to the new, very rapid progress can be made,  
47 because at about this time there is, generally, a complete revolution in the

1 public opinion of the whole establishment and practically all of the workmen  
2 who are working under the old system become desirous to share in the benefits  
3 which they see have been received by those working under the new plan.

4 Inasmuch as the writer has personally retired from the business of  
5 introducing this system of management (that is, from all work done in return  
6 for any money compensation), he does not hesitate again to emphasize the fact  
7 that those companies are indeed fortunate who can secure the services of  
8 experts who have had the necessary practical experience in introducing  
9 scientific management, and who have made a special study of its principles.  
10 It is not enough that a man should have been a manager in an establishment  
11 which is run under the new principles. The man who undertakes to direct the  
12 steps to be taken in changing from the old to the new (particularly in any  
13 establishment doing elaborate work) must have had personal experience in  
14 overcoming the especial difficulties which are always met with, and which are  
15 peculiar to this period of transition. It is for this reason that the writer  
16 expects to devote the rest of his life chiefly to trying to help those who  
17 wish to take up this work as their profession, and to advising the managers  
18 and owners of companies in general as to the steps which they should take in  
19 making this change.

20 As a warning to those who contemplate adopting scientific management, the  
21 following instance is given. Several men who lacked the extended experience  
22 which is required to change without danger of strikes, or without  
23 interference with the success of the business, from the management of  
24 "initiative and incentive" to scientific management, attempted rapidly to  
25 increase the output in quite an elaborate establishment, employing between  
26 three thousand and four thousand men. Those who undertook to make this change  
27 were men of unusual ability, and were at the same time enthusiasts and I  
28 think had the interests of the workmen truly at heart. They were, however,  
29 warned by the writer, before starting, that they must go exceedingly slowly,  
30 and that the work of making the change in this establishment could not be  
31 done in less than from three to five years. This warning they entirely  
32 disregarded. They evidently believed that by using much of the mechanism of  
33 scientific management, in combination with the principles of the management  
34 of "initiative and incentive," instead of with the principles of scientific  
35 management, that they could do, in a year or two, what had been proved in the  
36 past to require at least double this time. The knowledge obtained from  
37 accurate time study, for example, is a powerful implement, and can be used,  
38 in one case to promote harmony between the workmen and the management, by  
39 gradually educating, training, and leading the workmen into new and better  
40 methods of doing the work, or, in the other case, it may be used more or less  
41 as a club to drive the workmen into doing a larger day's work for  
42 approximately the same pay that they received in the past. Unfortunately the  
43 men who had charge of this work did not take the time and the trouble  
44 required to train functional foremen, or teachers, who were fitted gradually  
45 to lead and educate the workmen. They attempted, through the old-style  
46 foreman, armed with his new weapon (accurate time study), to drive the  
47 workmen, against their wishes, and without much increase in pay, to work much  
48 harder, instead of gradually teaching and leading them toward new methods,  
49 and convincing them through object-lessons that task management means for  
50 them somewhat harder work, but also far greater prosperity. The result of all  
51 this disregard of fundamental principles was a series of strikes, followed by  
52 the downfall of the men who attempted to make the change, and by a return to  
53 conditions throughout the establishment far worse than those which existed  
54 before the effort was made.

1 This instance is cited as an object-lesson of the futility of using the  
2 mechanism of the new management while leaving out its essence, and also of  
3 trying to shorten a necessarily long operation in entire disregard of past  
4 experience. It should be emphasized that the men who undertook this work were  
5 both able and earnest, and that failure was not due to lack of ability on  
6 their part, but to their undertaking to do the impossible. These particular  
7 men will not again make a similar mistake, and it is hoped that their  
8 experience may act as a warning to others.

9 In this connection, however, it is proper to again state that during the  
10 thirty years that we have been engaged in introducing scientific management  
11 there has not been a single strike from those who were working in accordance  
12 with its principles, even during the critical period when the change was  
13 being made from the old to the new. If proper methods are used by men who  
14 have had experience in this work, there is absolutely no danger from strikes  
15 or other troubles.

16 The writer would again insist that in no case should the managers of an  
17 establishment, the work of which is elaborate, undertake to change from the  
18 old to the new type unless the directors of the company fully understand and  
19 believe in the fundamental principles of scientific management and unless  
20 they appreciate all that is involved in making this change, particularly the  
21 time required, and unless they want scientific management greatly.

22 Doubtless some of those who are especially interested in working men will  
23 complain because under scientific management the workman, when he is shown  
24 how to do twice as much work as he formerly did, is not paid twice his former  
25 wages, while others who are more interested in the dividends than the workmen  
26 will complain that under this system the men receive much higher wages than  
27 they did before.

28 It does seem grossly unjust when the bare statement is made that the  
29 competent pig-iron handler, for instance, who has been so trained that he  
30 piles 3 6/10 times as much iron as the incompetent man formerly did, should  
31 receive an increase of only 60 per cent in wages.

32 It is not fair, however, to form any final judgment until all of the elements  
33 in the case have been considered. At the first glance we see only two parties  
34 to the transaction, the workmen and their employers. We overlook the third  
35 great party, the whole people, -- the consumers, who buy the product of the  
36 first two and who ultimately pay both the wages of the workmen and the  
37 profits of the employers.

38 The rights of the people are therefore greater than those of either employer  
39 or employee. And this third great party should be given its proper share of  
40 any gain. In fact, a glance at industrial history shows that in the end the  
41 whole people receive the greater part of the benefit coming from industrial  
42 improvements. In the past hundred years, for example, the greatest factor  
43 tending toward increasing the output, and thereby the prosperity of the  
44 civilized world, has been the introduction of machinery to replace hand  
45 labor. And without doubt the greatest gain through this change has come to  
46 the whole people -- the consumer.

47 Through short periods, especially in the case of patented apparatus, the  
48 dividends of those who have introduced new machinery have been greatly

1 increased, and in many cases, though unfortunately not universally, the  
2 employees have obtained materially higher wages, shorter hours, and better  
3 working conditions. But in the end the major part of the gain has gone to the  
4 whole people.

5 And this result will follow the introduction of scientific management just as  
6 surely as it has the introduction of machinery.

7 To return to the case of the pig-iron handler. We must assume, then, that the  
8 larger part of the gain which has come from his great increase in output will  
9 in the end go to the people in the form of cheaper pig-iron. And before  
10 deciding upon how the balance is to be divided between the workmen and the  
11 employer, as to what is just and fair compensation for the man who does the  
12 piling and what should be left for the company as profit, we must look at the  
13 matter from all sides.

14 *First.* As we have before stated, the pig-iron handler is not an extraordinary  
15 man difficult to find, he is merely a man more or less of the type of the ox,  
16 heavy both mentally and physically.

17 *Second.* The work which this man does tires him no more than any healthy  
18 normal laborer is tired by a proper day's work. (If this man is overtired by  
19 his work, then the task has been wrongly set and this is as far as possible  
20 from the object of scientific management.)

21 *Third.* It was not due to this man's initiative or originality that he did his  
22 big day's work, but to the knowledge of the science of pig-iron handling  
23 developed and taught him by some one else.

24 *Fourth.* It is just and fair that men of the same general grade (when their  
25 all-round capacities are considered) should be paid about the same wages when  
26 they are all working to the best of their abilities. (It would be grossly  
27 unjust to other laborers, for instance, to pay this man 3 6/10 as high wages  
28 as other men of his general grade receive for an honest full day's work.)

29 *Fifth.* As is explained (page 74), the 60 per cent increase in pay which he  
30 received was not the result of an arbitrary judgment of a foreman or  
31 superintendent, it was the result of a long series of careful experiments  
32 impartially made to determine what compensation is really for the man's true  
33 and best interest when all things are considered.

34 Thus we see that the pig-iron handler with his 60 per cent increase in wages  
35 is not an object for pity but rather a subject for congratulation.

36 After all, however, facts are in many cases more convincing than opinions or  
37 theories, and it is a significant fact that those workmen who have come under  
38 this system during the past thirty years have invariably been satisfied with  
39 the increase in pay which they have received, while their employers have been  
40 equally pleased with their increase in dividends.

41 The writer is one of those who believes that more and more will the third  
42 party(the whole people), as it becomes acquainted with the true facts, insist  
43 that justice shall be done to all three parties. It will demand the largest  
44 efficiency from both employers and employees. It will no longer tolerate the

1 type of employer who has his eye on dividends alone, who refuses to do his  
2 full share of the work and who merely cracks his whip over the heads of his  
3 workmen and attempts to drive them into harder work for low pay. No more will  
4 it tolerate tyranny on the part of labor which demands one increase after  
5 another in pay and shorter hours while at the same time it becomes less  
6 instead of more efficient.

7 And the means which the writer firmly believes will be adopted to bring  
8 about, first, efficiency both in employer and employee and then an equitable  
9 division of the profits of their joint efforts will be scientific management,  
10 which has for its sole aim the attainment of justice for all three parties  
11 through impartial scientific investigation of all the elements of the  
12 problem. For a time both sides will rebel against this advance. The workers  
13 will resent any interference with their old rule-of-thumb methods, and the  
14 management will resent being asked to take on new duties and burdens; but in  
15 the end the people through enlightened public opinion will force the new  
16 order of things upon both employer and employee.

17 It will doubtless be claimed that in all that has been said no new fact has  
18 been brought to light that was not known to some one in the past. Very likely  
19 this is true. Scientific management does not necessarily involve any great  
20 invention, nor the discovery of new or startling facts. It does, however,  
21 involve a certain combination of elements which have not existed in the past,  
22 namely, old knowledge so collected, analyzed, grouped and classified into  
23 laws and rules that it constitutes a science; accompanied by a complete  
24 change in the mental attitude of the working men as well as of those on the  
25 side of the management, toward each other, and toward their respective duties  
26 and responsibilities. Also, a new division of the duties between the two  
27 sides and intimate, friendly cooperation to an extent that is impossible  
28 under the philosophy of the old management. And even all of this in many  
29 cases could not exist without the help of mechanisms which have been  
30 gradually developed.

31 It is no single element, but rather this whole combination, that constitutes  
32 scientific management, which may be summarized as:

33 Science, not rule of thumb.

34 Harmony, not discord.

35 Cooperation, not individualism.

36 Maximum output, in place of restricted output.

37 The development of each man to his greatest efficiency and prosperity.

38 The writer wishes to again state that: "The time is fast going by for the  
39 great personal or individual achievement of any one man standing alone and  
40 without the help of those around him. And the time is coming when all great  
41 things will be done by that type of cooperation in which each man performs  
42 the function for which he is best suited, each man preserves his own  
43 individuality and is supreme in his particular function, and each man at the  
44 same time loses none of his originality and proper personal initiative, and  
45 yet is controlled by and must work harmoniously with many other men."

1 The examples given above of the increase in output realized under the new  
2 management fairly represent the gain which is possible. They do not represent  
3 extraordinary or exceptional cases, and have been selected from among  
4 thousands of similar illustrations which might have been given.

5 Let us now examine the good which would follow the general adoption of these  
6 principles.

7 The larger profit would come to the whole world in general.

8 The greatest material gain which those of the present generation have over  
9 past generations has come from the fact that the average man in this  
10 generation, with a given expenditure of effort, is producing two times, three  
11 times, even four times as much of those things that are of use to man as it  
12 was possible for the average man in the past to produce. This increase in the  
13 productivity of human effort is, of course, due to many causes, besides the  
14 increase in the personal dexterity of the man. It is due to the discovery of  
15 steam and electricity, to the introduction of machinery, to inventions, great  
16 and small, and to the progress in science and education. But from whatever  
17 cause this increase in productivity has come, it is to the greater  
18 productivity of each individual that the *whole country* owes its greater  
19 prosperity.

20 Those who are afraid that a large increase in the productivity of each  
21 workman will throw other men out of work, should realize that the one element  
22 more than any other which differentiates civilized from uncivilized countries  
23 -- prosperous from poverty-stricken peoples -- is that the average man in the  
24 one is five or six times as productive as the other. It is also a fact that  
25 the chief cause for the large percentage of the unemployed in England  
26 (perhaps the most virile nation in the world), is that the workmen of  
27 England, more than in any other civilized country, are deliberately  
28 restricting their output because they are possessed by the fallacy that it is  
29 against their best interest for each man to work as hard as he can.

30 The general adoption of scientific management would readily in the future  
31 double the productivity of the average man engaged in industrial work. Think  
32 of what this means to the whole country. Think of the increase, both in the  
33 necessities and luxuries of life, which becomes available for the whole  
34 country, of the possibility of shortening the hours of labor when this is  
35 desirable, and of the increased opportunities for education, culture, and  
36 recreation which this implies. But while the whole world would profit by this  
37 increase in production, the manufacturer and the workman will be far more  
38 interested in the especial local gain that comes to them and to the people  
39 immediately around them. Scientific management will mean, for the employers  
40 and the workmen who adopt it -- and particularly for those who adopt it first  
41 -- the elimination of almost all causes for dispute and disagreement between  
42 them. What constitutes a fair day's work will be a question for scientific  
43 investigation, instead of a subject to be bargained and haggled over.  
44 Soldiering will cease because the object for soldiering will no longer exist.  
45 The great increase in wages which accompanies this type of management will  
46 largely eliminate the wage question as a source of dispute. But more than all  
47 other causes, the close, intimate cooperation, the constant personal contact  
48 between the two sides, will tend to diminish friction and discontent. It is  
49 difficult for two people whose interests are the same, and who work side by  
50 side in accomplishing the same object, all day long, to keep up a quarrel.

1 The low cost of production which accompanies a doubling of the output will  
2 enable the companies who adopt this management, particularly those who adopt  
3 it first, to compete far better than they were able to before, and this will  
4 so enlarge their markets that their men will have almost constant work even  
5 in dull times, and that they will earn larger profits at all times.

6 This means increase in prosperity and diminution in poverty, not only for  
7 their men but for the whole community immediately around them.

8 As one of the elements incident to this great gain in output, each workman  
9 has been systematically trained to his highest state of efficiency, and has  
10 been taught to do a higher class of work than he was able to do under the old  
11 types of management; and at the same time he has acquired a friendly mental  
12 attitude toward his employers and his whole working conditions, whereas  
13 before a considerable part of his time was spent in criticism, suspicious  
14 watchfulness, and sometimes in open warfare. This direct gain to all of those  
15 working under the system is without doubt the most important single element  
16 in the whole problem.

17 Is not the realization of results such as these of far more importance than  
18 the solution of most of the problems which are now agitating both the English  
19 and American peoples? And is it not the duty of those who are acquainted with  
20 these facts, to exert themselves to make the whole community realize this  
21 importance?

22  
23 NOTES:

24 1. The writer has tried to make the reason for this unfortunate state of  
25 things clear in a paper entitled "Shop Management," read before the American  
26 Society of Mechanical Engineers."

27 2. For example, the records containing the data used under scientific  
28 management in an ordinary machine-shop fill thousands of pages.

29 3. See foot-note at foot of page 60.(i.e. note 4)

30 4. Many people have questioned the accuracy of the statement that first-class  
31 workmen can load 47 1/2 tons of pig iron from the ground on to a car in a  
32 day. For those who are skeptical, therefore, the following data relating to  
33 this work are given:

34 First. That our experiments indicated the existence of the following law:  
35 that a first-class laborer, suited to such work as handling pig iron, could  
36 be under load only 42 per cent of the day and must be free from load 58 per  
37 cent of the day.

38 Second. That a man in loading pig iron from piles placed on the ground in an  
39 open field on to a ear which stood on a track adjoining these piles, ought to  
40 handle (and that they did handle regularly) 47 1/2 long tons (2240 pounds per  
41 ton) per day.

1 That the price paid for loading this pig iron was 3 9/10 cents per ton, and  
2 that the men working at it averaged \$1.85 per day, whereas, in the past, they  
3 had been paid only \$1.15 per day.

4 In addition to these facts, the following are given:

5 47 1/2 long tons equal 106,400 pounds of pig iron per day.

6 At 92 pounds per pig, equals 1156 pigs per day.

7 42 per cent of a day under load equals 600 minutes; multiplied by 0.42 equals  
8 252 minutes under load.

9 252 minutes divided by 1156 pigs equals 0.22 minutes per pig under load.

10 A pig-iron handler walks on the level at the rate of one foot in 0.006  
11 minutes. The average distance of the piles of pig iron from the car was 36  
12 feet. It is a fact, however, that many of the pig-iron handlers ran with  
13 their pig as soon as they reached the inclined plank. Many of them also would  
14 run down the plank after loading the car. So that when the actual loading  
15 went on, many of them moved at a faster rate than is indicated by the above  
16 figures.

17 Practically the men were made to take a rest, generally by sitting down,  
18 after loading ten to twenty pigs. This rest was in addition to the time which  
19 it took them to walk back from the car to the pile. It is likely that many of  
20 those who are skeptical about the possibility of loading this amount of pig  
21 iron do not realize that while these men were walking back they were entirely  
22 free from load, and that therefore their muscles had, during that time, the  
23 opportunity for recuperation. It will be noted that with an average distance  
24 of 36 feet of the pig iron from the car, these men walked about eight miles  
25 under load each day and eight miles free from load.

26 If any one who is interested in these figures will multiply them and divide  
27 them, one into the other, in various ways, he will find that all of the facts  
28 stated check up exactly.

29 5. See paper read before the American Society of Mechanical Engineers, by  
30 Fred. W. Taylor, Vol. XVI, p. 856, entitled "Piece Rate System."

31 6. Time and again the experimenter in the mechanic arts will find himself  
32 face to face with the problem as to whether he had better make immediate  
33 practical use of the knowledge which he has attained, or wait until some  
34 positive finality in his conclusions has been reached. He recognizes clearly  
35 the fact that he has already made some definite progress, but sees the  
36 possibility (even the probability) of still further improvement. Each  
37 particular case must of course be independently considered, but the general  
38 conclusion we have reached is that in most instances it is wise to put one's  
39 conclusions as soon as possible to the rigid test of practical use. The one  
40 indispensable condition for such a test, however, is that the experimenter  
41 shall have full opportunity, coupled with sufficient authority, to insure a  
42 thorough and impartial trial. And this, owing to the almost universal  
43 prejudice in favor of the old, and to the suspicion of the new, is difficult  
44 to get.

1 7. First. The development of a true science. Second. The scientific selection  
2 of the workman. Third. His scientific education and development. Fourth.  
3 Intimate friendly cooperation between the management and the men.